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Graph-Theoretic Approach to Network Analysis

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Abstract: Networks are a class of general systems represented by their UC-structure. Suppressing the nature of elements the network becomes a weighted graph visualizing the constraints imposed by interconnections rather than the elements themselves. These constraints follow generalized Kirchhoff's laws derived from physical constraints. Once we have a graph; then the working environment becomes the graph-theory. An algorithm derived from graph theory is developed within the paper in order to analyze general networks. The algorithm is based on computing all the spanning trees in the graph G with an associated weight. This weight is the product of admittance's of the edges forming the spanning tree. In the first phase this algorithm computes a depth first spanning tree together with its cotree. Both are used as parents for controlled generation of off-springs. The control is represented in selecting the off-springs that were not generated previously. While the generation of off-springs, is based on replacement of one or more tree edges by cycle edges corresponding to cotree edges. The algorithm can generate a frequency domain analysis of the network.

Key words: UC-structure, network, spanning tree, depth-first search, spanning trees generation algorithm.

1. Introduction

A general system can be defined by the universe of discourse and couplings (UC-structure). That is, a system S is given by a set of elements, their permanent behaviors, and a set of couplings between the elements and environment.

In other words, a system S is defined by the 2-tuple

$$S = (B, C) \quad (1)$$

where $B = \{b_1, b_2, \ldots, b_r\}$ is the behaviors of the elements in the set of elements $A = \{a_0, a_1, \ldots, a_r\}$, a_0 denotes the environment, and $C = \{c_{ij} \mid c_{ij} = A_i \cap A_j, i \neq j\}$ is the set of couplings between elements, and A_i is the set of principle quantities on a_i, that is, a sampling of external quantities or observed quantities on a_i .

A class of UC-structure general systems is the network systems. Many physical and social systems are included in this class: For example, electrical systems, mechanical translation systems, mechanical rotational systems, thermal systems, managerial systems, experiential systems, etc [7, 8]. In a network the element represents a constraint. A second constraint is imposed by the network topology. This later constraint manifests itself in the application of generalized Kirchhoff's laws. That is, nodes in the network are non-accumulating and similarly its loops. The violation of the former law results in excessive continuous storage in one or more nodes, while violation of the later leads to unlimited amplifying loops or at least non observable loops. Both these phenomena are constrained in physical systems.

Topological properties of a network lead to the study of constraints imposed by the coupling laws. To this end, we start by suppressing the nature of individual elements. Therefore, we redraw the network with a line representing each branch of the network. The resulting outcome is the graph of the network.

The term topology is used in two meanings: (1) In modern mathematics, a "space" is a collection of elements together with some kind of mathematical structure governed by axioms. To specify a topological "structure" for a space is to specify a certain special class of subsets of elements, subject to certain axioms. These particular, subsets are called "open sets". The

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collection of all open sets forms what is called "the topology" of the space; (2) in geometry, topology is its branch studying those properties of spaces which depend only on their topologies and not other structural features of the space.

We are using this term on the second interpretation. Hence, topologically equivalent bodies are equivalent under all elastic deformations. That is, stretching, twisting, squeezing, pulling, or bending. Two networks are equivalent if there is an elastic deformation that leads from one network to the other. In addition, they are equivalent if they differ only in the elements constituting their branches.

A general system represented by its UC-structure may be expressed in the form of the general class of networks. Since the elements can be represented as the interconnection of bases elements in the form of integrators, differentiators, delay elements and multipliers [9]. The coupling between elements is depicted in the network topology. The frequency domain presentation of these elements is $1/j\omega x$, $j\omega x$, $e^{-j\omega T}$ and α, respectively.

A general system with multiple inputs can be analyzed similarly using the superposition principal. That is, the response due to each input is considered separately, and then the complete response is found by summing these partial responses.

A network with suppressed nature of its constituting elements is a weighted graph. Therefore, graph theory becomes the working environment.

2. A Graph-Theoretic Approach

2.1 Terminology

A graph G is an ordered pair of disjoint sets (V, E) such that E is a subset of the set of unordered pairs of V.

When the elements of E are ordered pairs, then G is a directed graph.

The set V is the finite set of vertices, and the set E is the finite set of edges. We shall not consider infinite graphs.

An edge {x, y} joins the vertices x and y, and is denoted by xy. If $xy \in E(G)$ then x and y are adjacent or neighboring vertices of G, and the vertices x and y are incident in the edge xy. The set of vertices adjacent to a vertex x is denoted by $\Gamma(x)$. Two edges are adjacent if they have exactly one common end vertex.

The order of a graph G is the number of vertices n, in G and is denoted by |G|. The size of G is the number of its edges m and denoted by e(G). The degree of a vertex x is the number of adjacent vertices $|\Gamma(x)|$ and is denoted by d(x). The minimum degree of a vertex in a graph is denoted by δ and its maximum degree by Δ. Since each edge has two vertices, then the sum of degrees of all vertices in a graph G is twice the number of edges.

A graph is simple if it has no loops (an edge joining a vertex to it) or multiple edges (two or more edges joining pairs of vertices in G). It is oriented when the positive direction is set for each edge.

If a real number is associated with each edge, then G is network or a weighted graph. In the present paper, we extended this term to include the association of a complex number to each edge.

The adjacency matrix A of a graph G is the n × n matrix having entries a_{ij} defined by:

$$a_{ij} = \begin{cases} 1 & \text{if } v_i v_j \in E(G) \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

The incidence matrix B of a graph G is the n × m matrix having entries b*ij* defined by:

$$b_{ij} = \begin{cases} 1 \text{ if } v_i \text{ is the initial vertex of the edge } e_i \\ -1 \quad \text{if } v_i \text{ is terminal vertex of } e_i \\ o \quad \text{otherwise} \end{cases} \quad (3)$$

In an independent set of vertices, no two elements are adjacent. Similar definition holds for edges. However, a set of paths is independent if for any two paths each vertex belonging to these two paths is an end vertex of both.

A walk W in G is an alternating sequence of vertices and edges, e.g., v0, e1, v1, e2…el, vl, where $e_i = v_i - v_i,\ 0 \le i \le 1$. This walk is denoted by v0, v1…vl, and its length is l.

A path is a walk with distinct vertices, hence it has distinct edges.

A trail is a walk with distinct edges, but not necessarily of distinct vertices. A closed trail (whose

end vertices coincide) is called a circuit. A closed path is a cycle.

A connected graph G is a graph in which there is a path for every pair of vertices $\{v_i, v_j\}$. If in G, there is two paths for each pair of vertices $\{v_i, v_j\}$, then G is bi-connected. If v_i and v_j are connected, then v_j and v_i are also connected.

A subgraph $G^{/}(V^{/}, E^{/})$ of the graph G (V, E) is a graph whose vertex set $V^{/} \subset V$, and edge set $E^{/} \subset E$. Hence we write $G^{/} \subset G$. If $G^{/} = G(V^{/})$, then $G^{/}$ is induced graph of G.

The relation R defined as v_i R v_j if v_i and v_j are connected is an equivalence relation. Hence, R partitions the set V into pair wise disjoint subsets of V. The subgraph induced by any such subset is a maximal connected subgraph. A maximal connected subgraph is a component of G.

If the deletion of a vertex increases the number of components in the graph G, then this vertex is a cut vertex. An edge defined similarly is a bridge.

A graph without any cycle is a forest. A connected forest is a tree. A forest having exactly two components is a thicket. Note that a forest is a disjoint union of trees.

A spanning tree of a graph is the tree that contains each vertex of the graph G. Each connected graph has at least one spanning tree.

Once a spanning tree is defined for a graph G, the remaining edges are called links or chords. Their collection is called a complementary tree or cotree.

A cut set is a minimal set of branches partitioning the vertex set V into two disjoint sets V_1 and V_2.

A fundamental loop is a loop that contains one and only one link. The number of fundamental loops is m – n +1.

A fundamental cut set is a cut set that contains one and only one spanning tree branch.

We define:

1. $\Omega = \{\omega_1, \omega_2, \ldots, \omega_k\}$ to be the set of frequencies at which the network is analyzed;

2. The source node s, and the sink node t;

3. The product of branch admittance's is denoted by w(T) for the spanning tree T of the graph G. We shall call w(T) the weight of T;

4. N is sum of weights of spanning tree in the graph G;

5. N (s, a, b, t) is the sum of weights of spanning trees of graph G in which the edge a b (in this order) occurs in the unique path from s to t;

2.2. The Approach

Several results from graph theory relate closely to network analysis. A cut set satisfies the generalized Kirchhoff's first law. Otherwise the components of a graph become accumulating. Also, the generalized second Kirchhoff's law is satisfied in any loop in the network. A spanning tree encompasses all nodes in the network by connecting them by exactly n – 1 independent branches. Thus, a spanning tree can provide the necessary n – 1 equations in n – 1 independent variables necessary for the network analysis. These variables are rates of displacements, that is, velocity in mechanical translation network, angular velocity in mechanical rotational networks, potential in electrical networks, temperature in thermal net-works, velocity in traffic networks, etc. Analogously, the flow in the m – n +1 links enables the calculation of the flow in each of the n – 1 branches by summing up the flow in the n – 1 fundamental cut sets. The exact meaning of flow is class dependent. It is the force in mechanical translation networks, torque in mechanical rotation networks, current in electrical networks, rate of heat flow in a thermal network, and rate of cars in a traffic network, etc.. If we define loop flows for each of the fundamental loops, we can obtain the n – 1 independent edge flows, since each link is incorporated in exactly one fundamental loop. By applying the second generalized Kirchhoff's law to each fundamental loop we obtain a set of independent equations.

Theorem 1: Assuming a unit flow to the source node s, and out of the sink node t, then the flow in the edge ab

(in this order) in the weighted oriented graph (oriented network) is given by $w_{ab} = \{N(s, a, b, t) - N(s, b, a, t)\}/N$. The assumption of unit flow is not restrictive, since normalization of flow is always possible.

Proof: it is necessary and sufficient to verify the generalized Kirchhoff's laws.

At the source node s for each spanning tree there exists exactly one neighbor v(T) of s that is in the s-t path contained in T; denoted as P(T). Therefore,

$$\sum_{b\in\Gamma(s)} N(s,s,b,t) = N \tag{4}$$

While

$$\sum_{b\in\Gamma(s)} N(s,b,s,t) = 0 \tag{5}$$

Hence,

$$\sum_{b\in\Gamma(s)} w_{sb} = 1 \tag{6}$$

That is, the generalized Kirchhoff's first law is satisfied at s.

By a similar argument, it follows that this law is satisfied at the sink node t. That is:

$$\sum_{a\in\Gamma(t)} w_{at=1} \tag{7}$$

Let us assume no other node is an input or output node. Assume further that each value w is multiplied by N. Then the contribution of a spanning tree T to the current entering vertex v_i then leaving it falls in one of the two cases:

(1) If v_i is not on the s-t path contained in T, P(T), then no contribution of T to either N(s, v_j, v_i, t) or N(s, v_i, v_k , t);

(2) If v_i is on the s-t path P(T) then T contributes w(T) to N(s, v_j, v_i, t) and N(s, v_i, v_k, t) where v_j, v_i, v_k are three consecutive nodes in the path P(T), that is, the contribution of T is w(T) to the current into v_i and the same to current out of v_i. Thus the first law is satisfied.

To verify the second generalized Kirchhoff's law let us de-fine a thicket F as:

$$F = F_s \cup F_t \tag{8}$$

where, F_s is the component that comprises source node s, and F_t is the component with sink node t.

However, the thickets contributing to the rate of displacement in cycle including the vertices a, b are those for which $a \in F_s$ and $b \in F_t$ or vice versa. Then the contribution of a thicket F to the total rate of displacement in a cycle is their algebraic sum over cycle edges. This sums to zero since the rate of displacement over each edge is w_{ab}/D, where D is admittance of the branch and the thicket is contributing to w_{ab} and w_{ba} by the same value of weight. To illustrate the verification of the second generalized Kirchhoff's law, look at Fig. 1.

The contribution of the cycle between a, b vertices to f_t is by D_{eq}. However,

$$f_{T1} = f_T \frac{D_1}{D_{eq}} \quad \text{, and} \quad f_{T2} = f_T \frac{\frac{D_2 D_3}{D_2 + D_3}}{D_{eq}} \tag{9}$$

The rate of displacement on each edge is the corresponding flow over the edge's admittance's. Hence the sum of the rate of displacement around the cycle is zero.

In the theorem 1, it is necessary to compute N, N(s, a, b, t) and N (s, b, a, t) to determine w_{ab}. These are the outcomes of the genetic-like algorithm in Sec. 3. However, a pre-computation of the number of spanning trees and their weights can serve as end criterion or as a verification of the algorithm. This is the topic of the following theorem.

Theorem 2: The number of spanning trees of G is $|\mathbf{B}\mathbf{B}^t|$.

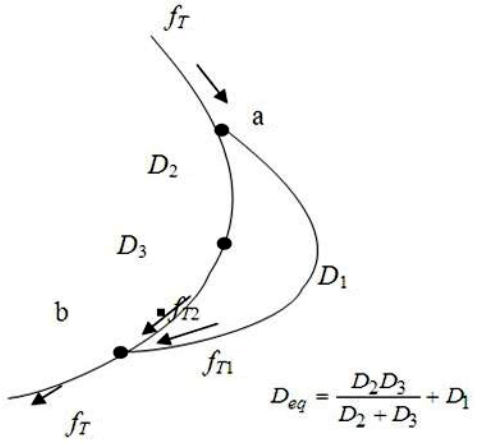

Fig. 1 Illustration of generalized second Kirchoff's law.

Proof: The proof is based on two observations:

The determination of an (n – 1) × (n – 1) submartix of B is "1" if the columns correspond to edges of a spanning tree and "0" otherwise;

The Cauchy-Binet formula of linear algebra, stating that if K is a p × q matrix (p ≤ q) and L is a q × p matrix then:

$$|\mathbf{KL}|=\sum_p |\mathbf{K}_p\mathbf{L}_p| =\sum_p |\mathbf{K}_p||\mathbf{L}_p| \qquad (10)$$

where the summation is over all subsets P of {1, 2, ..., q}, and $\mathbf{K_p}$ is the p ×p submatrix of **K** formed by the columns of **K** indexed with elements of P and $\mathbf{L_p}$ is submatrix of **L** formed by the corresponding rows of **L**.

Theorem 2 is useful in computing N(s, a, b, t) and N(s, a, b, t) and N (s, b, a, t). This requires forming the transition matrix $\mathbf{B_{sa}}$, $\mathbf{B_{at}}$, $\mathbf{B_{bt}}$, $\mathbf{B_{sb}}$ of the components of G comprising s, a; a, t; b, t and s, b. Then N(s, a, b, t) is the lower of the two numbers $|\mathbf{B_{sa}}\ \mathbf{B_{sa}}^t|$ and $|\mathbf{B_{bt}}\ \mathbf{B_{bt}}^t|$. N(s, b, a, t) is found similarly.

3. A Genetic-Like Algorithm

The computation of the following algorithm is to be repeated for each $\omega_i = i$ in the set Ω, i = 1… k. In the first phase of the algorithm a spanning tree is found using the depth first search algorithm (DFS), while preserving enough information about links (chords, or cycle edges).

3.1 The DFS Algorithm

(1) Initialization: k ← 1; j ← 1; i ← 1; V(k) ← v_i;

(2) Test of end: if k = n, then GoTo 7; Else process d(v_k); i ← i+1;

(3) Process tree edge: if v_i, v_kv_i are not labeled, then, label v_{ij}; e(k)←v_kv_i; k ← k+1; V(k) ← v_i; Goto2; Else Goto 4;

(4) Another infant: if v_i is not labeled, v_k v_i is labeled; j < d(v_k) then j← j + 1; Goto3; Else Goto 5;

(5) Backtracking if j = d(v_k); and i ≠ 1, then, k ← k – 1;i ← i – 1; Goto 2; Else Goto 6;

(6) Check of connectedness: If i = 1; k < n (it is a must at this point), then output: "Graph is not connected"; End;

(7) Cycle Edges: ic ← 1; for i = 1, m do: If e(ic) ≠ E(l), then ic ← ic + 1; ec(ic) = l;

The DFS algorithm fails if G is not connected. In this case, an error message is edited. The initialization of i ← 1 is not a must. We may start the algorithm from any vertex other than s. Then instead of i ← i + 1 in (2) we use i ← mode (i + 1, n) + 1, and i ≠ i_0, in (5) and i = i_0 in (6) where $i_0 \in [1, n]$ in the initialization of i ← i_0 in (1).

If the graph G was connected then the resulting acyclic graph of n vertices and n – 1 edges is a spanning tree. This is the initial spanning tree.

The time complexity of the DFS algorithm is ϑ(n + 2m) if the pseudo-statements do need constant time. The basic operation is comparison. Each edge could be at most investigated twice; hence there are at most 2m edge investigations. There are at most n vertices to be labeled. Hence, the above order is an upper limit. Since a graph can have at most C_2^n edges, that is, n(n – 1)/2 edges, then the worst case time complexity is $\vartheta(n^2)$.

The space complexity is ϑ(n) apart from the requirements of the graph representation. The final effect of DFS algorithm; if succeeded, is to partition the edge set E of graph G into two disjoint sets, namely, the set of tree edges, and the set of cycle (chords, or link) edges.

The functions encountered in the DFS algorithm are:

(1) VERTEX: v → [1, n]. Defined by: VERTEX [v] = k ⇔ v is the k'th vertex processed;

(2) TREE_EDGE: E → [1, n – 1]. Defined by, TREE_EDGE (i) = e_i ⇔ e_i is a tree edge, i = 1, n – 1;

(3) CYCLE_EDGE: E → [1, m – n + 1]. Defined by CYCLE_EDGE (i) = e_i ⇔ e_j is a cycle edge, j = 1, m – n + 1;

(4) V_PARENT: v → {True, False}. Defined by

$$\text{V\_PARENT (v)} = \begin{cases}\text{True} & \text{v} \notin \text{VERTEX(v)} \\ \text{False} & \text{otherwise}\end{cases},$$

(5) E_PARENT: E → {True, False}. Defined by:

$$\text{E\_PARENT (e)} = \begin{cases}\text{True} & \text{e} \notin \text{TREE\_EDGE (e)} \\ \text{False} & \text{otherwise}\end{cases}.$$

Only Vertex imposes space requirements. The TREE_EDGE and CYCLE_EDGE functions are marked on the initial graph representations.

In terms of these functions the DFS algorithm may be written as in the following:

```
Proc DFS
begin
k: = i: = j: = 1
VERTEX (k): = v_i
Process test_ END
Process tree_edge
If V_PARENT (v_k) = False and E_PARENT (v_k v_i)
= True and j< dk then
begin
j: = j + 1
Process tree_edge
end;
else
if j = dk and i ≠ 1 then
begin
k: = k – 1
i: = i – 1
process test-end
end;
else
if i = 1 and k = 1 then
begin
output, 'graph is not connected'
end DFS
end

Process test-end
if k = n then
begin
Process End_DFS
end;
else
dk = d(v_k)
Process tree_edge
If V_PARENT (v_k) and E_Parent (v_k v_i) then
begin
Tree_EDGE (k): = v_k v_i
k: = k + 1
V (k): = v_i
Process test_end
end.

Process END_DFS
ic: = 1
for l: = 1 step 1 until m do
if TREE_EDGE (ic) ≠ E(l) then
begin
ic: = ic + 1
CYCL_EDGE (ic) = l
end;
end.
```

A FORTRAN-77 program listing of DFS Subroutine is depicted in the appendix together with associated functions V and NST.

Once an initial spanning tree T1 and a cotree are determined, then we may proceed by generating off-springs from these as parent strings. The addition of a chord (link) to the computed spanning tree produces a fundamental loop. Off-springs can be generated so, by deleting one edge of the cycle (except the link) successively. Thus a number of off-springs equals the length of the cycle minus "1" is generated. It is necessary to prove that the generated off-springs are all different from previously computed spanning trees.

Theorem 3: The addition of a link (cycle edge) to a spanning tree produces a cycle of length, say l. Then it is possible to generate l-1 off-springs, each is a spanning tree, by deleting successively one tree edge from the so formed fundamental loop. Repeating this argument with off-springs as parents and all possible segmentations of the cotree, all the spanning trees of the graph G will be generated.

The inputs to the spanning trees generation algorithm are the initial spanning tree (the output of DFS algorithm), the cotree, and the transition matrix of graph G. After generating a spanning tree its weight

is computed. Then its contribution to N, N(s, a, b, t), and N(s, b, a, t) is determined. Thus the flow in the edge ab is computed by theorem 1.

3.2 Spanning Trees Generation Algorithm

```
Proc STG (i)
BEGIN
KEY: = True; CYCL_LENGTH: = TREE_RANK: =1
EC[CYCLE_LENGTH]: = CYCLE_EDGE (i)
v1: = VER1(CYCLE_EDE(i)); v2: = VER2(CYCL_EDGE));
for l: = v2 step 1 until n – 1 do
CYCL_LENGTH: = CYCL_LENGTH + 1
EC[CYCL_LENGTH]: = TREE_EDGE(l)
if VERTEX (l) = v1 then
begin
Proc TREE;
KEY: = False
end;
if KEY then
begin
CYCL_LENGTH: =1
for l: = v2 step-1 until 1 do
CYCL_LENGTH: = CYCL_LENGTH + 1
EC (CYCL_LENGTH): = TREE_EDGE(;)
if VERTEX(l): = v1 then
begin
proc TREE
end;
end;
end.
w(1): =1
for j: = 1 step 1 until n – 1 do
T1(j): = TREE_EDGE(j)
w(1) = w(1) * C (INV_EdGE (TREE_EDGE [j]))
end;
for i = m – n + 1 step-1 until 1 do
proc STG (i)
end;
N: =0; N1: =0; N2: = 0
for l: =1 step 1 until TREE_RANK do
N = N + w(l)
end;
for j: =1 step1 until TREE_RANK do
for l: =1 step1 until n – 1 do
if Tj (l) = eab and VER1(eab) = a then
begin
N1 = N1 + w(j)
end;
else
If Tj(l) = eab and VER1(eab) = b then
begin
N2 = N2 + w(j)
end;
end;
wab = (N1 – N2)/N
end.
```

Let the number of spanning trees in G be NT. Hence the space complexity of the STG algorithm is NT(n – 1). However, NT = (m – n + 1) * LC_{max}, in the worst case, where LC_{max} is the maximum cycle length. Therefore, in the worst case the space complexity depends on LC_{max} = n. That is, the space complexity is $\vartheta(n^2)$ in the worst case. The time complexity in terms of the basic operations number, that is, comparisons of off-springs is (n – 2) [$LC_1 + LC_2 + \ldots + LC_{n-m+1}$] which is once more $\vartheta(n^2)$. The computation requires NT(n – 1) basis operations, that is, $\vartheta(n^2)$. Hence, the time and space complexity of the algorithm are both of order n^2 in the worst case.

There are two more functions to use within the STG algorithm. These are:

(1) INV_EDGE: [1, n] $\rightarrow$ E. Defined by INV_EDGE[l] = k $\Leftrightarrow$ E(k) = l;

(2) INV_VERTEX: [1, n] $\rightarrow$ V. Defined by INV_VERTEX[l] = k $\Leftrightarrow$ V (k) = l.

The first do loop in the above procedure creates the function (array) EC defining the string of edges in the cycle formed by adding the edge of the cotree. The function VER1(e) returns the initial vertex of the edge e, and VER2(e) returns its end vertex.

3.3 Process Tree

```
TR: = TREE_RANK
for j: = 1 step 1 until TREE_RANK do
TR: = TR + 1
for l: = 1 step 1 until n – 1 do
T_TR (l): = T_j (l)
end;
end;
iv: = INV_VERTEX (v_2)
for j: = 1 step1 until CYCL_LENGTH-1 do
for l: 1 step1 until j do
T_TR (iv – j + CYCL_LENGTH-1+l): = EC(l)
end;
process TEST
TREE_RANK: = TR
w(TR): = 1
for kw: = 1 step1 until n – 1 do
w(TR): = w(TR)*C(INV_EDGE (T_TR [kw])
end;
end.

Process TEST
TR: = TR + 1
for j: =1 step 1 until TR-2 do
if T_TR-1: = T_j then
begin
TR: = TR-2
end;
end.
```

The statement $T_{TR-1} = T_j$ is to be expanded during programming. For example, the criterion for comparison may be chosen as the sum of edges numbers in the tree. Since the sum of n natural numbers is equal if an only if there is a one-to-one correspondence between the elements in each set.

When the weights of edges are complex, then it is necessary to repeat all computation for each element of Ω. This does not require the computation of all spanning trees once more. It just requires computing the weights of the resulting spanning trees for each ω_i.

To illustrate the usefulness of the algorithm we consider the bridge network in Fig. 2.

Direct computation gives flow of –2/21 in the edge ab. The number of spanning trees in the network is NT = 8.The algorithm generates these as shown in Fig. 3.

The computation of flow in the edge ab by the given algorithm results in w_{ab} = -.0.09524 which compares well with the value –2/21 within round-off.

3. Summary and Conclusions

General systems representation is possible using their UC-structure. This structure alone, or combined with other representations, may serve as a system description Networks can serve as an important general class of the system's representations. Subclasses of networks are electrical systems, mechanical transnational systems, mechanical rotational systems, the thermal systems, traffic systems, social systems, etc..

When the nature of elements in a network is suppressed then the network is a weighted graph.

Therefore graph theory may present the working environment for network analysis. In this paper an algorithm based on theorem1 was derived. The nature of the algorithm is similar to genetic algorithm but with rather controlled off-springs generation. The parent strings are generated by a depth-first-search (DFS) algorithm. The output of DFS, if successful, is two strings one is the spanning tree and the second is the cotree. These are used in a spanning tree generation (STG)

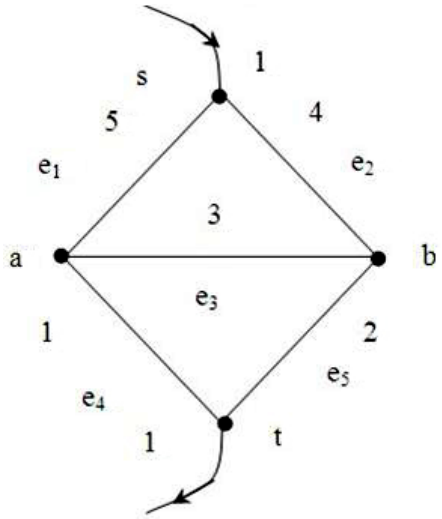

Fig. 2 An example bridge network.

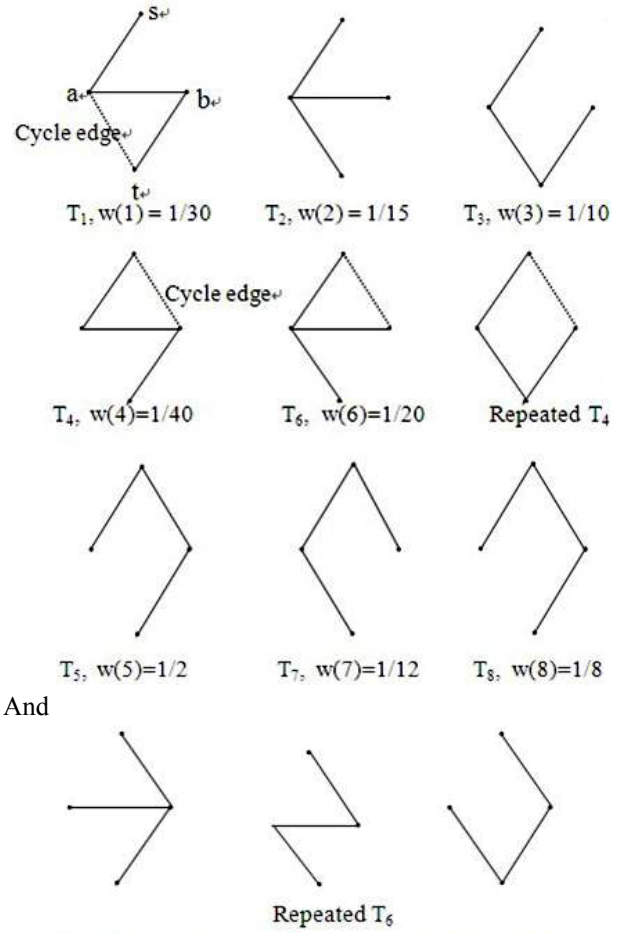

Fig. 3 Generation of spanning tree.

algorithm for generating the spanning trees and performing the requested analysis. The algorithm is applied successfully for the analysis of a number of networks. An example is presented within the paper.

When the weights, that is, the numbers associated with edges, are complex, then the analysis is repeated for each frequency in the set Ω. Hence, the frequency response analysis is performed.

References

[1] A.J. Kfoury, R.N. Moll, M.A. Arbib, A Programming Approach to Computability, Springer Verlag, NewYork, 1982..

[2] A.E. Taylor, General Theory of Functions and Integration, Dover Publications, Inc, New York, 1985.

[3] B. Bollabas, Graph Theory: An introductory Course, Springer Verlag, New York, 1979.

[4] S. Even, R.E. Tarjan, Computing an st-numbering, Theoretic Computer Science (2) (1976) 393-344 and (4) (1977) 123.

[5] G.M. Weinberg, A computer approach to general systems theory, in: George J. Klir (Ed.), Trends in General Systems Theory, Wiley—Interscience, New York, 1972.

[6] J.W. Nilson, Electric Circuits, fourth Ed., Adison Wisely Publishing Company, New York, 1993.

[7] J.J. D'Azzo, G.H. Houpis, Feedback Control Systems Analysis & Synthesis, second Ed., Mc Graw—Hill International, London, 1966.

[8] J.H. Milsum, The hierarchical basis of general living systems, in: George J.Klir (Ed.), Trends in General Systems Theory, Wiley Interscience, New York, 1972.

[9] Prof. Dr. Nabil Hassan, Analog & Digital Systems Analysis and Design, Dar Al Maarefa, Cairo, 1996.

[10] Prof Dr. Nabil Hassan, The Art of Programming in FORTRAN, Dar Al Ketab Al Hadeeth, Cairo, 1996.

[11] R.A. Orchard, On an Approach to General Systems Theory, Wiley—Interscience, New York, 1972.

[12] W. Stallings, Data and Computer Communication, second Ed., Mc millan Publishing Company, New York, 1989.

[13] V.K. Balakrishman, Introductory Discrete Mathematics, Prentice-Hall International, Englewood cliffs, New Jersy, 1991.

Appendix

```
SUBROTINE DFS(IB, NV, ME, LE, K, NT, N, M, MAG, MEG)
DIMENSION IB(N, M), MAG(N1), MEG(N1),
+NV(NT, N), ME (NT, N – 1), LE(2)
* MAG array is a temporal store for neighbor vertices.
* MEG array is a temporal store for neighbor edges.
* Logical function V excludes the previously used edges of current tree.
* Logical variable key is used to extract cycle edges (chords) after the spanning tree is found.
LOGICAL V, KEY
DATA KEY/. TRUE./
DO 40 IU = 1, N – 1
MAG (IU) = 0
40 MEG (IU) = 0
*IT variable determines the rank of current parent.
IV = 1
IT = 1
KK = K
```

```
NV(1,1) = K
2 IF (IV. EQ.N) GOTO 100
* Call of function NST
IJ = NST(MAG,MEG,IB,K,N,M)
* Note:K variable here is used for the current vertex.
DO 1 J = IT, IJ
K = MAG (J)
IF (V(K, NV, NT, N) THEN
*KE variable symbolizes the computed neighbor edge.
* IV variable symbolizes the rank of that edge.
KE = MEG (J)
ME (1, IV) = KE
IV = IV +1
GOTO 2
ENDIF
1 CONTINUE
* Test of connectedness of the graph.
IF (IV.EQ.KK.AND.IV.LT.N) THEN
PRINT *'GRAPH IS NOT CONNECTED!!'
GOTO 100
ENDIF
* Note: K here is the parent in the spanning tree of the, current
vertex.
K = NV (1, IV-1)
IT = IT +1
GOTO 2
IK = 0
* Test of the previous use of the current edge.
DO 3 I2 = 1, M
DO 4 I3 = 1, N – 1
IF (ME(1, I3).NE.I2) GOTO 4
KEY = FALSE.
4CONTINUE
IF (KEY) THEN
IK = IK+1
LE (IK) = I2
ENDIF
KEY = .TRUE.
3CONTINUE
K = KK
RETURN
END
*The logical function V returns true when the input vertices not
included in the list computed spanning tree vertices.
LOGICAL FUNCTION V(K, NV, NT, N)
DIMENSION NV(NT,N)
V = .TRUE.
DO 1 I = 1, N
IF (K.NE.NV (1, I) GOTO 1
V = .FALSE.
GOTO 100
1 CONTINUE
100RETURN
END
* Function NST (Neighbor of current vertex in the Spanning
*Tree) stores spanning tree edges in MEG,
* spanning tree vertices in MAG, and returns. The number of
*determined spanning tree vertices.
FUNCTION NST (AG, MEG, IB, II, N, M)
DIMENSION MAG(N – 1), MEG(N – 1), IB(N, M)
* II variable is the rank input vertex.
* IJ variable is the rank of current neighbor.
IJ = 0
DO 1 I = 1, M
* Row II search in IB matrix for the first neighbor edge.
If (IB(II, II).EQ.0) GOTO 1
* K variable stores the current neighbor vertex.
K = 0
IJ = IJ + 1
MEG (IJ) = I
4K = K + 1
IF (IB(K, I).EQ.0.OR.K.EQ.II) GOTO 2
MAG (IJ) = K
* Test of end of the computing loop.
2IF (K.LT.N) GOTO 4
1CONTINUE
*NST takes the value of IJ, rank of final neighbor.
NST = IJ
RETURN
END
```

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Stumbling Blocks in Cloud Computing Adoption Pathway: A Charter

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Abstract: Cloud computing is currently an embryonic domain in the area of information technology that possesses the power of transforming the way information technology (IT) services are delivered and maintained in the business world. Pay as per the usage kind of cost structure coupled with delivery of computing services through internet makes cloud computing an exciting and potential growth oriented information technology model compared with conventional computing services delivery models. Various additional features like scalability, flexibility and easy deployment process creates a window for the organizations even relatively smaller in size to get benefitted by the highly advanced & modern technologies without incurring substantial cost. In spite of so many benefits of this new delivery model, concerns are beginning to grow about how safe an environment it is. Despite of all the hype surrounding the cloud, enterprise customers are still reluctant to deploy their business in the cloud. Security is one of the major issues which reduces the growth of cloud computing and complications with data privacy and data protection continue to plague the market. Other related concerns associated with the adoption of cloud computing include trust on service providers, loss of control and compliance issues. This paper is an attempt to explore security & trust issues linked with cloud computing adoption in the Small and Medium Enterprises (SME) sector.

Key words: Cloud computing, privacy, security and SME.

1. Introduction

Enterprises decide to invest in information systems for many reasons which include pressure to cut cost, pressure to produce more without increasing costs and simply to improve quality of services or products in order to stay in business [1]. Information and Communication Technologies (ICT) provide large variety of benefits to firms in the form of reduced business costs, enhanced productivity, improved business cooperation and relationships and improved quality and diffusion of knowledge [2]. Conventionally, companies are required to acquire necessary hardware and software to computerize and improve their business processes. Expert IT personnel are required to manage information system infrastructure. Rapid growth and advancements in IT further pose additional challenges to companies to keep up with these changes thereby compelling companies to continuously spend more time and resources in information technology in order to remain competitive [2]. Cloud computing provides businesses an altogether different model of operation in which providers are responsible for hard parts of using software such as installation, up-gradation, maintenance, backups, failover operations and security, thus resulting in huge cost savings and increased reliability on the part of users [3].

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Organizations that are evaluating the benefits of cloud based services must also identify the associated operational and security risks in order to develop compensating controls or to define use cases that contain an acceptable level of risk [4]. Organizations that are planning to move to cloud are required to be fully aware about the issues concerning privacy, loss of control, security of data, vendor lock-in issues and perceived trust on Cloud Service Providers (CSPs). For cloud computing to be a success, providing a simplified, convenient, and centralized platform that can be used as and when required, irrespective of the location, calls for sufficient attention to the challenges and concerns of the various stake holders associated with it [5].

The paper is organized as follows. A brief overview of cloud computing is provided in the next section followed by relevance of cloud computing for SMEs. Cloud computing benefits are explained in the next section followed by concerns of cloud computing. Security and trust are explored in detail in the next sections. Conclusion is provided at the end.

2. A Brief Overview of Cloud Computing

There are a number of definitions of cloud computing and some of these are discussed here. As mentioned in Ref. [6] cloud computing refers to both applications delivered as services through internet and the hardware and system software in the data centres that provide those services and cloud has been referred to as the data canter hardware and software. As per [7], cloud computing encompasses a whole range of services and can be hosted in a variety of manners, depending on the nature of services involved and the data/security needs of the contacting organizations. Gartner defined cloud computing as a style of computing where massively scalable IT related capabilities are provided as a service across the internet to multiple external customers [8].

According to Ref. [9], the basic point of cloud computing is to avoid acquiring and maintaining computer equipment and software, increase the ease of use and flexibility of the benefit offered by the technology. Cloud allows a start-up organization to access the same technology infrastructure and support as a Fortune 500 company [10]. As in Ref. [11] cloud computing is a means of renting computers, storage and network capacity on an hourly basis from some company that already has these resources in its own data centre and can make them available to a company and company's customers via the internet. "Ref. [12] points out that whether it is called cloud computing or on demand computing, software as a service or internet as platform, the common element is a shift in the geography of computation." As per [13] the easiest way to think about cloud computing is as doing business on the web, therefore eliminating the need for in-house technology infrastructure-servers and software to purchase, run and maintain. Authors in Ref. [14] defined cloud computing as a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreements established through negotiations between the service providers and consumers.

Definition of cloud computing as provided in Ref. [15] emphasized on aspects such as resource utilization, virtualization, architecture abstraction, dynamic resource scalability elasticity, ubiquity and operational expenses. As in Ref. [16] three major characteristics of cloud computing definition are highlighted which include demand provisioning of scalable resources, virtualization, and maintenance & management free. It has been observed in Ref. [17] that there is no any common standard definition of cloud computing, however the definition that described cloud computing as a cluster of distributed computers capable of providing on demand resources and service over some kind of network, has found to be commonly accepted.

National Institute of Standard & Technology (NIST) has specified three main cloud computing service models which are—Cloud Infrastructure as a service

(IaaS), Cloud Platform as a service (PaaS) and Cloud Software as a Service (SaaS). Four cloud deployment models which are further mentioned by NIST include—Private cloud (where cloud infrastructure is operated solely for one particular organization), Community cloud (where the cloud infrastructure supports a specific community and is shared by several organizations of that community), public cloud (where cloud infrastructure is made available to the general public) and hybrid cloud (a composition of two or more clouds that remain unique entities but are bound together by standardized or proprietary technology) [18].

3. The Relevance of Cloud Computing for SMEs

Cloud Computing was initially shaped for commercial purposes in 2007 by companies like Google and Amazon. Cloud Computing technology and resources are based on the concepts like virtualization, centralized data centers, dynamically adjusted and tuned to achieve optimum efficiency, providing an unparalleled economy of scale. Cloud computing alter computing power into a public utility like water, electricity or gas supplies [19]. From the perspective of an SME, the benefits of Cloud-based technologies are: low start-up costs, low cost for irregular use, ease of management, scalability, device and location independence and rapid innovation. Cloud computing offers the opportunity for SMEs to subscribe to pay-per-use top class solutions at an affordable price and fulfill their operational needs to access infrastructure, platform and software over the Internet, without having to host or maintain the services themselves [20]. SMEs are realizing that cloud computing can have tangible benefits and are seriously considering their transition to cloud technologies [17]. SMEs stand to gain from exceptional features of cloud computing like pay-per-use, high performance computing scenario enabling them to encourage innovation and improve their competitiveness. Ability to provide immediate cost savings, increased productivity and improved responsiveness to the business makes cloud computing an attractive alternative model for SMEs [21].

Authors in Ref. [22] have made an attempt to find out scope of cloud computing for SMEs in India. The authors have considered two factors namely cost saving and reduction in the level of difficulty in adopting cloud computing service enabled ERP system. The study has shown that the average amount saved by using cloud based ERP is about 3,7000 (INR) per user per year for the SMEs under consideration as compared to the traditional ERP. The other proposition supported in the study includes greater ease of adaptability in case of cloud based application than in traditional applications. Authors in Ref. [23] have investigated the adoption and perceptions of cloud computing by SMEs in South Africa. The study has revealed that SMEs are aggressively adopting cloud computing adoption in South Africa. The study shows that most SMEs currently adopting cloud computing share a unique profile like: they are small, work in the IT industry, and have business owners who are technologically proficient enough to drive the cloud adoption process themselves.

4. Cloud Computing Benefits

As mentioned in Ref. [11] main business benefits of cloud computing include scalability, cost advantage and automatic updates and upgrades. The ability to plug in to IT services via the cloud opens up many, often transformational opportunities, well beyond technology efficiencies and cost savings. These include easy deployment; increased speed to market; leveraging collective mind-share and development efforts of the extended cloud computing; shifting IT spending from a capital expense to an operating expense [10]. Authors in Ref. [9] believe that flexible pricing on a pay-for-use basis is a big piece of value proposition, along with the rapid increase and decrease of usage with minimal involvement by the service

provider. As in Ref. [7], there are eight fundamental elements that are vital in enabling the cloud computing concept which include universal connectivity, open access, reliability, interoperability, security, privacy, economic value and sustainability. Ref. [13] shows that major benefits of cloud computing as pointed out by vendors and analysts include quick implementation process, lower up-front costs, easier and more regular updates, disaster recovery and back up capabilities etc. The key advantages identified in Ref. [15] include lower cost of entry for smaller firms trying to benefit from the latest information technologies; faster time to market; lower IT barriers to innovation and scalability. Author in Ref. [24] observes that both client and provider are benefited by cloud computing where client gets on demand access to computing resources with no upfront expenses and provider gets benefited by efficient utilization of physical resources through efficient distribution. He further states that society as a whole too gets benefited by cloud computing in terms of less physical hardware equipments, better efficiencies, less power consumption leading to green computing.

5. Cloud Computing Concerns

Cloud computing is an emerging computing service paradigm and like other services of this type, there are certain concerns, fears and uncertainties associated with it and major among these are control, vendor lock-in, performance, latency, security, privacy and reliability [17]. “Ref. [20] mentioned that based on a survey conducted by IDC in 2008, the major challenges that prevent cloud computing from being adopted by the organization include security, performance, availability, hard to integrate with in-house IT, and not enough ability to customize.” Authors in Ref. [6] highlighted three critical obstacles to the growth of cloud computing which might affect its adoption which include availability/business continuity, data lock-in, data confidentiality and audit ability. Privacy of business and personal information has been mentioned as one of the major downside of cloud computing in Ref. [25] which includes a set of complex and comprehensive issues and a cautious approach is recommended to be adopted by users and providers while moving to the cloud. Thus security, privacy, loss of control, availability and perceived trust on service providers emerge out to be the major concerns associated with cloud computing adoption. Security & trust are discussed in detail in the following sections.

6. Security

Due to the nature of Cloud computing with its multi-tenancy and shared resources characteristics, there is a risk of failure in the infrastructure, potentially exposing important information. Even though cloud computing’s benefits are incredible, security and privacy concerns are the key obstacles to its extensive adoption. Since cloud service providers are separate administrative entities, moving to the commercial public cloud deprives users of direct control over the systems that manage their data and applications. In spite of powerful and reliable infrastructure and management capabilities of CSP which are much more than those of personal computing devices, the cloud platform still faces both internal and external security and privacy threats, including media failures, software bugs, malware, administrator errors and malicious insiders [26]. The authors in Ref. [27] surveyed 200 IT professionals in order to observe their security & privacy concerns associated with cloud computing environment. Major concerns as highlighted in this survey included security (93.8 per cent), governance (61.1 per cent) and a lack of control over service availability (56.6 per cent). The survey also showed that most of the IT professionals were unaware about the fact that some of the CSPs currently control the decryption keys that enable them to decrypt their client’s data. This factor should also be considered as a major security concern. Companies who have been a victim of the cloud attack identified data loss and

leakage as the biggest threat. It is felt that security would become one of the primary differentiators among CSPs. A survey conducted by Everest Group also highlighted perceived security issues as the most significant barrier to cloud computing adoption [28].

Ref. [29] shows that the key elements that should be considered carefully in the cloud deployment process.

6.1 Data Security

In a conventional on-premise application deployment model, the sensitive data of enterprise continues to reside within the enterprise boundary and it is in direct control of the enterprise. However, in cloud computing, the enterprise data is stored outside the enterprise boundary, at the cloud service provider end. As a result, the provider must adopt additional security checks to ensure data security and prevent breaches due to security vulnerabilities in the application or through malicious employees.

6.2 Network Security

In a cloud computing environment IT services are provided through internet Sensitive data and information reside and transmitted over network. The flow of data over the network needs to be secured in order to prevent leakage of sensitive information. Proper security mechanism is required to be implemented at this layer. This involves the use of strong network traffic encryption techniques such as Secure Socket Layer (SSL) and the Transport Layer Security (TLS) for security.

6.3 Data Locality

In cloud environment, consumers use the applications provided by the cloud service provider and process their business data. But in such a scenario, customer does not know where the data is getting stored. This might be having serious implications. Due to compliance and data privacy laws in various countries, locality of data is of utmost importance in much enterprise architecture. For example, in many EU and South America countries, certain types of data cannot leave the country because of potentially sensitive information. In addition to the issue of local laws, there's also the question of whose jurisdiction the data falls under, when an investigation occurs [30].

6.4 Data Confidentiality

Cloud computing involves sharing or storage of their information by users on remote servers owned or operated by others and accesses through internet or other connections. Cloud computing services exist in many forms, including data storage sites, video sites, tax calculation sites, personal health record websites and many more. The whole contents of a user's storage device may be stored with a single cloud service provider or with many cloud service providers. Whenever any organization shares information in the cloud, privacy or confidentiality questions arise. Therefore, the issues like privacy of personal information and confidentiality of business information are quite apparent in such a computing environment. Privacy and confidentiality risks differ considerably with the terms of service and privacy policy established by the cloud provider. For some types of information and some types of cloud computing users, privacy and confidentiality rights, responsibilities, and position may change when a user discloses information to a cloud provider. Disclosure and remote storage may have unfavorable consequences for the legal status of protections for personal or business information. The location of information in the cloud may have major effects on the privacy and confidentiality protections of information and on the privacy obligations of those who process or store the information. Information in the cloud may spread over many geographic locations having different legal systems. Laws could force a cloud provider to examine user records for evidence of criminal activity and other matters. Legal doubts make it difficult to assess the status of information in the cloud as well as the privacy and confidentiality

protections available to users [31].

In a market survey by Ernst & Young's, 72% of the respondents indicated data privacy and security issues to be the extremely significant concerns [32]. 50% participants termed privacy as the main concern regarding the use of cloud computing, in a survey carried out by KPMG [33].

7. Perceived Trust on Service Providers

Trust is an important factor in most of the economic and social transactions where some degree of uncertainty is involved. Perceived trust has strong linkage with customer's willingness to adopt an innovation [34]. Security and trust is the degree to which customers consider that using cloud computing is safe and reliable in terms of data security, service availability and application compatibility. Perceived security and trust can help in reducing confusion associated with the adoption of new technologies [35]. Under the cloud computing paradigm, an organization surrender direct control over many aspects of security and privacy which calls for a high level of trust onto the cloud provider. Establishing a level of trust about a cloud service is something which also depends on the extent of control an organization is having on the provider concerning security checks necessary to protect the organization's data and applications, and also the evidence provided about the effectiveness of those controls by service provider. This may not be viable in many cases. Eventually, if the level of trust in the service falls below expectations and the organization is unable to employ compensating controls, it must either reject the service or accept a greater degree of risk [36]. An interview study conducted by VTT Technical Research Centre of Finland in 2010 revealed that the most important factor affecting perceived trust in cloud services is brand, including such sub-aspects as reputation, image, history and name of the CSP. Security & Privacy and Transparency and Reliability were the second and third most important aspects [37].

Trust issues become mainly important when data processing is decentralized across geographically dispersed data centers and resources are distributed beyond a definable and controllable border, which is especially true in the cloud computing scenario [38]. Current trends for trust establishment adopted by CSPs include different approaches like-SLAs, audits, measuring and ratings, and self assessment questionnaire. These trends are mostly ad-hoc and either considering technical and functional features or the user feedback for establishing trust on CSPs. Thus, these trends are lacking a unified approach [39].

8. Conclusions

While cloud computing promises to deliver significant technical and business benefits to adopters, this is also true that it is still a developing market. When considering the use of cloud services or technologies, it is important to first determine whether available services deliver measurable benefits or not. So a cautious approach is recommended on the part of customers who are planning to use cloud computing in some form. Different surveys & reports suggest that providers are also aware about the customers' concerns and are working on addressing these issues. In order to achieve large scale adoption of cloud computing and to clear the air about growing concerns arising from this new technology, providers are required to educate cloud customers about cloud and its implications for their businesses. They should clearly demonstrate to their customers how they are adhering to different standards & certifications regarding data security & privacy. This may help in getting a sense of security & trust amongst potential cloud customers. Further research is recommended in the areas like reliability of cloud, social issues in cloud computing and security & privacy concerns in cloud computing for different types of businesses.

References

[1] P. Legris, J. Ingham, P. Collerette, Why do people use

information technology? A Critical Review of the Technology Acceptance Model, Information and Management 40 (2003) 191-204.

[2] V. Barbra-Sanchez, M. Martinez-Ruiz, A. Jimenez-Zarco, Drivers, challenges and benefits of ICT adoption by Small and Medium-sized Enterprises (SMEs): A literature review, Problems and Perspective in Management 5 (1) (2007) 103-113.

[3] W.Y.C. Wang, A. Rashid, H.M. Chuang, Towards the trend of cloud computing, Journal of Electronic Commerce Research 12 (4) (2011) 238-242.

[4] D. Truong, How cloud computing enhances competitive advantages: A research model for small businesses, The Business Review 15 (1) (2010) 59-65.

[5] Gartner Research, Cloud Computing: Defining and describing an Emerging Phenomenon, 2008, ID Number:G00156220

[6] C. Rose, A break in the cloud—The reality of the cloud computing, International Journal of Management and Information Systems 15 (4) (2011) 59-63.

[7] M. Armbrust, A. Fox, R. Griffith, A.D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, M. Zaharia, A view of cloud computing, Communications of the ACM 53 (2010) 50-58.

[8] D. Wyld, Cloud computing around the world, Multilingual January/February, 2010, pp. 44-48.

[9] Gartner Report. [Online], 2009, http://www.gartner.com/DisplayDocument? id=685308.

[10] W.M. Ryan, C.M. Loeffler, Insights into cloud computing, Intellectual Property & Technology Law Journal 22 (11) (2010) 22-27.

[11] M. Goodburn, S. Hill, The cloud transforms business, Financial Executive, December, 2010, pp. 35-39.

[12] R. Smith, Computing in the Cloud, Research Technology Management (2009) 65-68.

[13] B. Hayes, Cloud computing, Communications of the ACM (51) (2008) 9-11.

[14] A. De Flice, Cloud Computing: What accountants need to know, Journal of Accountancy, October, 2010, pp. 50-55.

[15] R. Buyya, C.S. Yeo, S. Venugopa, J. Broberg, I. Brandic, Cloud computing and emerging it platforms: vision, hype, and reality for delivering computing as the 5th utility, Future Generation Computer Systems 25 (2009) 599-616.

[16] S. Marston, Z. Li, S. Bandyopadhyay, J. Zhang, A. Ghalsasi, Cloud computing- the business perspective, Decision Support Systems 51 (2011) 176-189.

[17] D. Truong, How cloud computing enhances competitive advantages: A research model for small businesses, The Business Review 15 (1) (2010) 59-65.

[18] N. Sultan, Reaching for the cloud: How SMEs can manage, International Journal of Information Management 31 (2011) 272-278.

[19] The NIST definition of cloud computing (draft), National Institute of Standard & Technology Special Publication 800-145 (draft) 7 pages, January 2011.

[20] F.C. Marta, A.M.R. Correia, F.T. Neves, Supporting KMS through cloud computing: A scoping review, the 6th Iberian Conference on Information Systems and Technologies (CISTI), Chaves, 15-18 June 2011.

[21] T. Dillon, W. Chen, E. Chang, Cloud computing: Issues and challenges, the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA), 20-23 April, 2010.

[22] F.T. Neves, F.C. Marta, A.M.R.C. Correia, M.C. Neto, The Adoption of cloud computing by SMEs: Identifying and coping with external factors, 11ª Conferência da Associação Portuguesa de Sistemas de Informação (CAPSI 2011)—A Gestão de Informação na era da Cloud Computing, Lisboa, ISEG/IUL-ISCTE/, 19-21th Oct 2011.

[23] M. Sharma, A. Mehra, H. Jola, A. Kumar, M. Misra, V. Tiwari, Scope of cloud computing for SMEs in India, Journal of Computing 2 (5) (2010).

[24] C. Hinde, J.P. Van Belle, Cloud Computing in South African SMMEs: Risks and rewards of playing at altitude, International Journal of Computer Science and Electrical Engineering 1 (1) (2010) 1-10.

[25] A. Bajenaru, Software-as-a-Service and cloud computing, a solution for small and medium-sized companies, Bulletin of the Transylvania University of Brasov 3 (52) (2010) 173-184.

[26] H. Katzan, On the privacy of cloud computing, International Journal of Management and Information Systems 14 (2) (2010) 1-12.

[27] P. Legris, J. Ingham, P. Collerette, Why do people use information technology? A critical review of the technology acceptance model, Information and Management (40) (2003) 191-204.

[28] A. Aleem, C.R. Sprott, Let me in the cloud: analysis of the benefit and risk assessment of cloud platform, Journal of Financial Crime 20 (1) (2013) 6-24.

[29] Everest Group, Guidelines on Security and Privacy in Public Cloud Computing, August, 2012.

[30] T. Saxena, IT Security Issue in Cloud Computing Model, in: Proceedings of International Conference on Cloud, Big Data and Trust 2013, Nov. 13-15, pp. 170-178.

[31] V. Choudhary, Software as a service: implications for investment in software development, in: Proceeding of International Conference on System Sciences, 2007, pp. 209.

[32] S. Subashini, V. Kavitha, A survey on security issues in service delivery models of cloud computing, Journal of Network and Computer Applications 34 (2011) 1-11.

[33] Ernst and Young, Cloud adoption in India-Infrastructure as a Service: trends and perception in the Indian Market, May 2011, pp. 6-41.

[34] KPMG's 2010 Cloud Computing Survey [Online], http://www.kpmg.com/ES/es/ActualidadyNovedades/ArticulosyPublicaciones/Documents/2010-Cloud-Computing-Susrvey.pdf.

[35] P. Pavlou, Consumer acceptance of e-commerce: integrating trust and risk with the technology acceptance model, International Journal of Electronic Commerce 7 (3) (2003) 69-103.

[36] H. Awa, M. Bari, B. Inyang, The uptake of electronic commerce by SMEs: A meta theoretical framework expanding the determining constructs of TAM and TOE frameworks, Journal of Global Business and Technology 6 (1) (2010) 1-18.

[37] W. Wu, Developing an explorative model for SaaS adoption, Expert Systems with Applications 38 (2011) 15057-15064.

[38] NIST Special Publication 800-144, Guidelines on Security and Privacy in Public Cloud Computing, December, 201

[39] I. Uusitalo, K. Karppinen, A. Juhola, R. Savola, Trust and cloud services-an interview study, Cloud Computing Technology and Science (CloudCom), IEEE Second International Conference on. IEEE, 2010.

[40] S.M. Habib, S. Hauke, S. Ries, M. Mühlhäuser, Trust as a facilitator in cloud computing: A survey, Journal of Cloud Computing: Advances, Systems and Applications 1 (19) 2011.

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Power System Stability Improvement by Using STATCOM with POC & Excitation Controller

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Abstract: This paper presents the model of a static synchronous condenser (STATCOM) which is controlled externally by a newly designed power oscillation controller (POC) for the improvements of power system stability and damping effect of an on line power system. The proposed POC consists of two controllers (power oscillation damping & proportional integral derivative PID & POD). PID parameters have been optimized by Zigler Necles close loop tuning method. Machine excitation has been controller by using excitation controller as required. Both single phase and three phase faults has been considered in the research. In this paper, a power system network is considered which is simulated in the phasor simulation method & the network is simulated in three steps: without STATCOM, with STATCOM but no externally controlled, STATCOM with POC. Simulation result shows that without STATCOM, the system parameters become unstable during faults. When STATCOM is imposed in the network, then system parameters become stable. Again, when STATCOM is controlled externally by POC controllers, then system voltage & power becomes stable in faster way then without controller. It has been observed that the STATCOM ratings are only 20 MVA with controllers and 200 MVA without controllers. Therefore, STATCOM with POC controllers are more effective to enhance the voltage stability and increases power transmission capacity of a power system. So STATCOM with POC & excitation controllers, the system performance is greatly enhanced.

Key words: STATCOM, voltage regulator, power system controller, PID, POD, POC and MATLAB simulink.

1. Introduction

Power system stability improvements are very important for large scale system. The AC power transmission system has diverse limits, classified as static limits and dynamic limits [1-2]. Traditionally, fixed or mechanically switched shunt and series capacitors, reactors and synchronous generators were being used to enhance same types of stability augmentation [3]. For many reasons, desired performance was being unable to achieve effectively. A STATCOM is an electrical device for providing fast-acting reactive power compensation on high voltage transmission networks and it can contribute to improve the voltage profiles in the transient state and therefore, it can improve the qualities and performances of the electric services [3]. An STATCOM can be controlled externally by using properly designed different types of controllers which can improve voltage stability of a large scale power system. In previous study, authors has d signed a PID controller which has tuned by Triple Integral Differential (TID) tuning method [4]. However, in this study, With a view to get better performance, a new POC has been designed & proposed for STATCOM to inject V_{qref} externally for the improvement of power system stability. The dynamic nature of the STATCOM lies in the use of thyristor devices (e.g. GTO, IGCT) [3]. Therefore, thyristor based STATCOM with POC controllers has been used to

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improve the performance of power system.

2. Control Concept of STATCOM

A STATCOM, also known as a "static synchronous condenser", is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power, it can also provide active AC power. It is a member of the FACTS family of devices. Usually, a STATCOM is installed to support electricity networks that have a poor power factor and often poor voltage regulation. A STATCOM is a voltage source converter (VSC)-based device, with the voltage source behind a reactor. The voltage source is created from a DC capacitor and therefore a STATCOM has very little active power capability. However, its active power capability can be increased if a suitable energy storage device is connected across the DC capacitor. The reactive power at the terminals of the STATCOM depends on the amplitude of the voltage source [5].

3. Power System Model

This example described in this section illustrates modeling of a simple transmission system containing 2-hydraulic power plants (Fig. 1). STATCOM has been used to improve transient stability and power system oscillations damping. The phasor simulation method can be used. A single line diagram represents a simple 500 kV transmission system (Fig. 1) [6]. A 1000 MW hydraulic generation plant (M1) is connected to a load centre through a long 500 kV, total 700 km transmission line.

A 5000 MW of resistive load is modelled as the load centre. The remote 1000 MVA plant and a local generation of 5000 MVA (plant M2) feed the load. A load flow has been performed on this system with plant M1 generating 950 MW so that plant M2 produces 4046 MW. The line carries 944 MW which is close to its surge impedance loading (SIL = 977 MW). To maintain system stability after faults, the transmission line is shunt compensated at its centre by a 200MVAR STATCOM (Fig. 2).

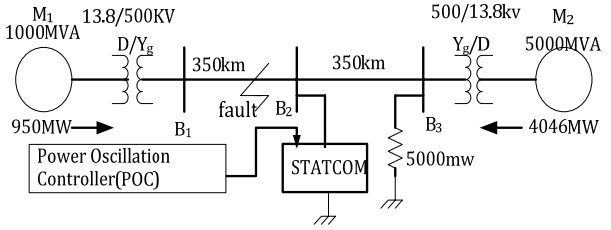

Fig. 1 Single line diagram of 2-machine power system.

The STATCOM does not have any controller unit. Machine & STATCOM parameters have been taken from Ref. [5]. The complete simulink model of STATCOM with power system controller is shown in Fig. 4. To maintain system stability after faults, the transmission line is shunt compensated at its centre by a 200MVAR STATCOM with power system controller. The two machines are equipped with a hydraulic turbine and governor (HTG) (Fig. 2), excitation system. Any disturbances that occur in power systems due to fault can result in inducing electromechanical oscillations of the electrical generators. Such oscillating swings must be effectively damped to maintain the system stability.

4. Simulation Results

The load flow solution of the above system is calculated and the simulation results are shown below: Two types of faults—single line to ground fault and three phase fault have been considered.

4.1 Single Line to Ground Fault

Consider a 1-phase fault occurred at 0.1s & circuit breaker is opened at 0.2s (4-cycle fault). Without STATCOM, the system voltage, power & machines oscillates go on unstable (Fig. 3 and Fig. 5). But if STATCOM (without controller) is applied, then voltage becomes stable within 3s (Fig. 4), power becomes within 3s (Fig. 6). All results has been summarized in table-I.

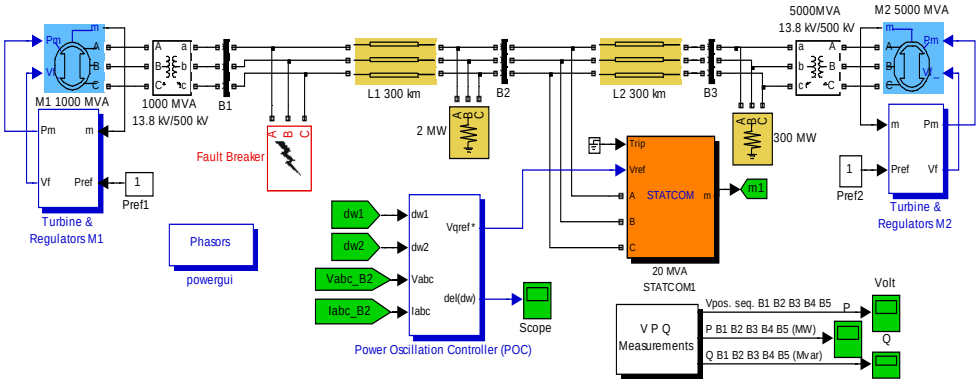

Fig. 2 Complete simulink model of 2-machine power system.

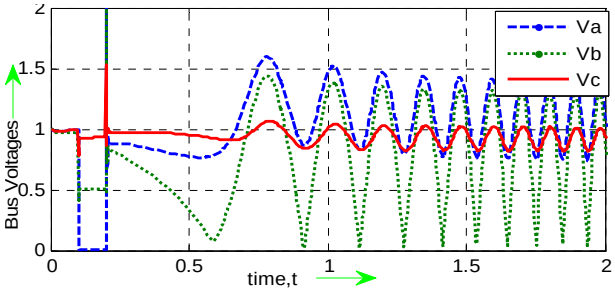

Fig. 3 Bus voltages in p.u for 1-phase fault (without STATCOM).

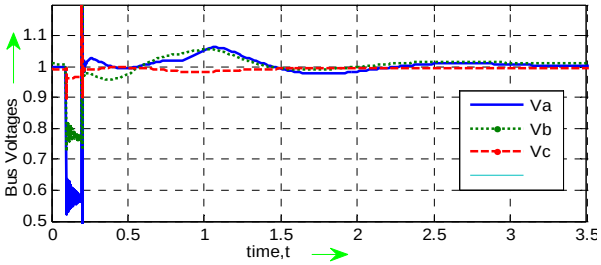

Fig. 4 Bus Voltages in p.u for 1-phase fault (with STATCOM).

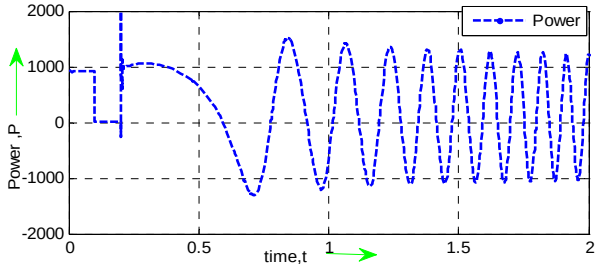

Fig. 5 Bus power, P in MW during fault (without STATCOM)).

5. Design of Power Oscillation Controller

The proposed power oscillation controller consists of two parts—A PID controller which is tuned by Zieglar-Nicles method [4] & POD controller. PID

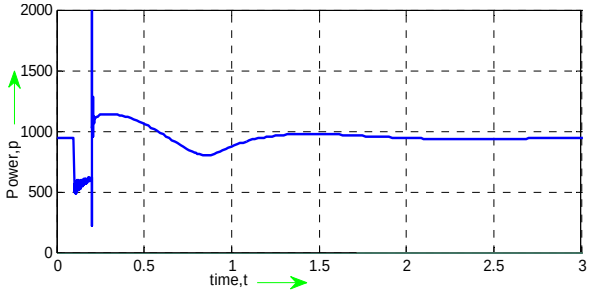

Fig. 6 Bus power (P) in MW for 1-Ø faults (with STATCOM).

controller takes input as machines angular speed deviation and gets an error signal & POD controller takes input as line voltage & line current & after damp out the oscillation it also gives as error signal. Finally, the proposed power oscillation controller takes input as all parameters of power system network i.e. V_{abc}, I_{abc}, dω & it gives an error signal (V_{qref}) which injects STATCOM for improvement of power system stability.

5.1 Designed of PID Controller

The process of selecting the controller parameters to meet given performance specifications is called PID tuning. Most PID controllers are adjusted on-site, many different types of tuning rules have been proposed in the literature [4]. Using those tuning rules, delicate & fine tuning of PID controllers can be made on-site. Also automatic tuning methods have been developed and some of the PID controllers may possess on-line automatic tuning capabilities [4].

The PID controller has three term control signal [4],

$$u(t) = K_p e(t) + \frac{K_p}{T_i}\int e(t)dt + K_p T_d \frac{de(t)}{dt} \quad (1)$$

In Laplace form,

$$\frac{U(s)}{E(s)} = K_p\left(1 + \frac{1}{T_i} + T_d s\right) \text{(Fig. 7)} \quad (2)$$

For selecting the proper controller parameters, Ziegler-Nichols PID Tuning [4], second Method is described below.

In the 2nd method, the parameter is selected as $T_i = \infty$, $T_d = 0$. Using the proportional controller action (Fig. 4) only increase K_p from 0 to a critical value K_{cr}. At which the output first exhibits sustained oscillations (Fig. 9).

Thus the critical gain K_{cr} & the corresponding period P_{cr} are experimentally determined. Ziegler and Nichols suggested that the values of the parameters K_p, T_i and T_d should set according to the following formula:

$K_p = 0.6\ K_{cr}$, $T_i = 0.5\ P_{cr}$, $T_d = 0.125\ P_{cr}$

Notice that the PID controller tuned by the 2nd method of Ziegler-Nichols rules gives,

$$G_C(s) = K_p\left(1 + \frac{1}{T_i * S} + T_d S\right) \quad (3)$$

$$G_C(s) = 0.6K_{cr}\left(1 + \frac{1}{0.5P_{cr} * S} + 0.125\,P_{cr} S\right) \quad (4)$$

$$G_C(s) = 0.075\ K_{cr} * P_{cr}\ \frac{\left(S + \frac{4}{P_{cr}}\right)^2}{S} \quad (5)$$

Thus the PID controller has a pole at the origin and double Zeros at $S = -4/P_{cr}$ (Fig. 10).

The critical gain (K_{cr}) for which the plant output gives a sustained oscillation (Fig. 9) is determined for this network ($K_{cr} = 200$) and corresponding period of P_{cr} (Fig. 9) is also determined from Fig. 9 and found $P_{cr} = 0.2$. Thus the transfer function or parameters of PID controller is determined based on Ziegler-Nichols tuning method (Eq. 1) which is shown in Fig. 11. During faults, the machines angular speed deviation (dω) & mechanical power (Pm), line voltage, line current, power all are changed. So, dω & pm are taken as the input parameters of newly designed PID controller.

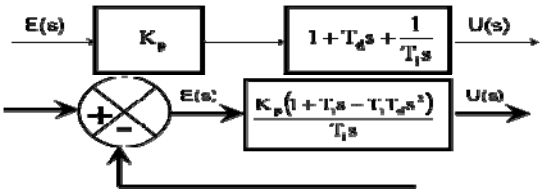

Fig. 7 Block diagram of PID controller parameters.

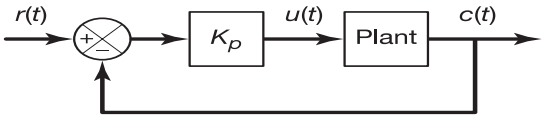

Fig. 8 PID controller is in proportional action.

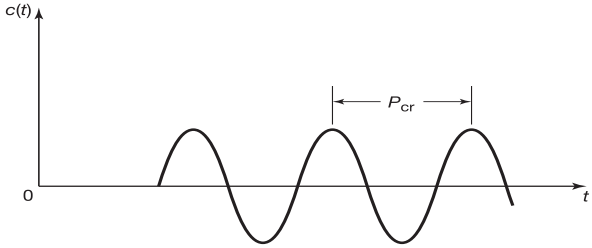

Fig. 9 Determination of sustained oscillation (P_{cr}).

Fig. 10 PID controller with tuning parameters.

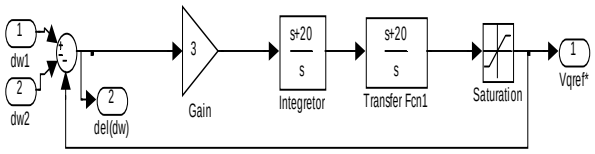

Fig. 11 Internal structure of PID controller.

The proposed PID controlled SVC simulink model is shown in the Fig. 11.

5.2 Designed of POD Controller

The POD controller (Fig. 12) takes input as V_{abc} and I_{abc} and converts as power. If no faults have occurred, then switch remains open. But when fault occurred then switch becomes closed & after filtering or damp out oscillation, it also gives an error signal & finally two error signal has been added & this is V_{qref}.

5.3 POC

The proposed POC consists of both two controllers (PID & POD) (Fig. 13) which injects V_{qref} in

STATCOM further improve the power system stability.

6. Design of Excitation Controller

Alternator prime mover consists of HTG & Excitation block. Alternator state can be sensed by a feedback. If any faults occur in network, then HTG changes the speed of machine and machine excitation can be changed by excitation controller. Inside the excitation controller, a MATLAB program has been set so that machine excitation will change as required to regain system stability.

7. Simulation Results with POC

The network remains same (Fig. 2), just simple STATCOM is replaced by power system controlled STATCOM. During fault, machines speed deviation ($d\omega$), line voltage (V_{abc}) and line current (I_{abc}) are always monitored by power system controller. Taking input of those oscillations, after processing as shown in Fig. 13, it reduces damping of power system oscillation and helps STATCOM to improve stability. Two types of faults have been considered—single line to ground fault and three phase fault.

7.1 Single Line to Ground Fault

During 1-phase faults, if POC is used as STATCOM controller, then the system voltage becomes stable within 0.25s with 0% damping (Fig. 15) and power (P,Q) becomes stable within 0.25s (Fig. 16).

7.2 Three Phase Fault

During 3-phase faults, If POC is used as STATCOM controller, then the system voltage becomes stable within 0.25s (Fig. 17) and both power, P becomes stable within 0.25s (Fig. 18).

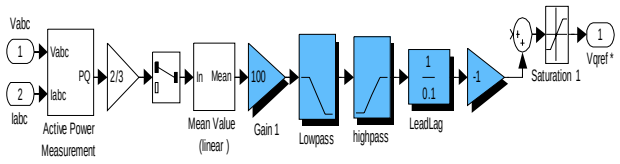

Fig. 12 Internal structure of POD controller.

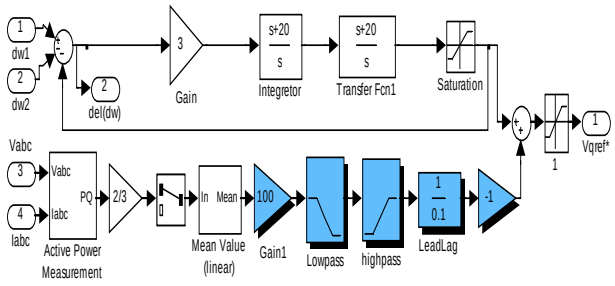

Fig. 13 Internal structure of power system controller (PSC).

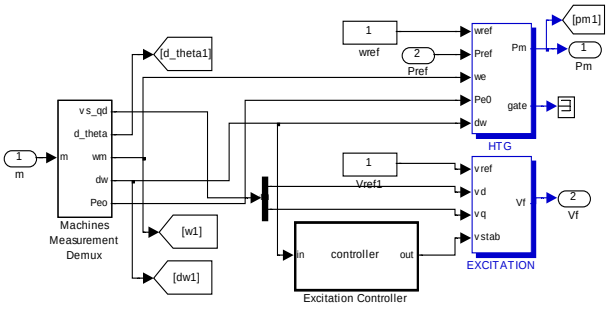

Fig. 14 HTG & excitation block with controller.

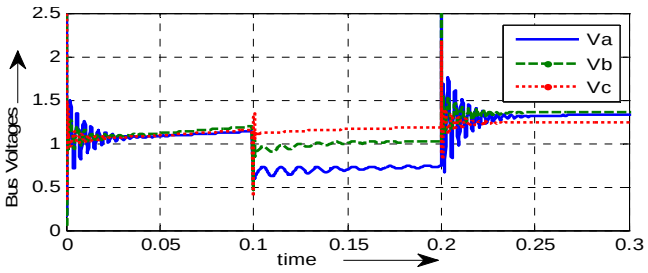

Fig. 15 Bus voltage in p.u for 1-Ø fault (with POC).

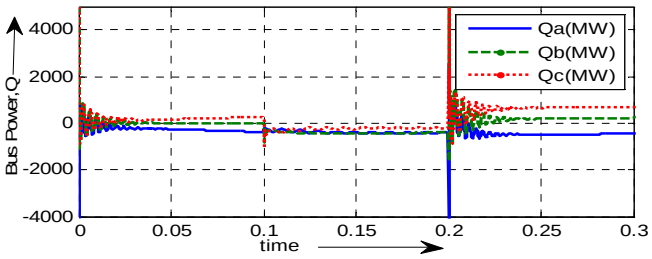

Fig. 16 Bus pwer, Q for 1-Ø fault in MW (with POC).

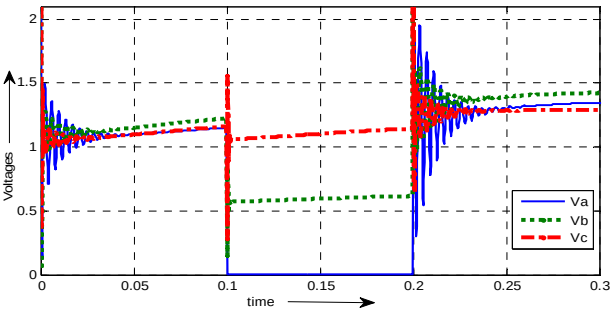

Fig. 17 Bus voltages in p.u for L-L fault (with POC).

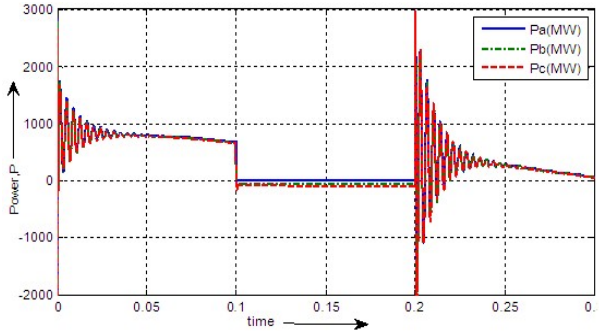

Fig. 18 Bus power, P in MW for L-L fault (with POC).

Table 1 Performance of proposed Power Oscillation Controller (POC).

Controller	STATCOM rating	1-Øfault (stability time)		3-Øfault (stability time)	
		Volt	P,Q	volt	P,Q
No STATCOM	0 MVA	α	α	α	α
STATCOM	200 MVA	3s	3s	5s	5s
STATCOM + POC	20 MVA	0..25s	0.25s	0.25s	0.25s

8. Results and Discussion

The performance of the proposed power oscillation controller with STATCOM has been summarized in the Table 1. In Table 1, α (infinite time) means the system is unstable, STATCOM rating in MVA. The network is simulated in three steps; without STATCOM, With STATCOM only, STATCOM with proposed POC & Excitation controller.

9. Conclusions

This paper presents the power system stability improvement, i.e. voltage level, machine oscillation damping and real power system model of STATCOM without or with proposed power oscillation controller for different types of faulted conditions. POC is also a very efficient controller then others for STATCOM to enhance the power system stability. From above results, this proposed Zigler-Nicles close loop tuning method for selecting PID controller parameters & POD, in combine, Power oscillation controller may be highly suitable as a STATCOM controller because of shorter stability time, simple designed, low cost and highly efficient controller. Machines DC excitation can also be controlled easily by using excitation controller. Rather that, if POC controller is used, then only small rating of STATCOM becomes enough for stabilization of robust power system within very shortest possible time for both steady state and dynamic conditions. These proposed power oscillation controller can be applied for any interconnected multi-machine power system network for stability improvement.

These controller can be applied to another FACTS devices namely SSSC, UPFC whose controllers may be controlled externally by designing different types of controllers which also may be tuned by using different algorithm i.e. fuzzy logic, ANN, Genetic algorithm and FSO etc. for both transient and steady state stability improvement of a power system.

References

[1] H.F. Boroujeni, M. Amani, M. Abdollahi, Dynamic stability improvement by using STATCOM in a multi machine environment, Research Journal of Applied Sciences, Engineering and Technology 4 (18) (2012) 3505-3509.

[2] M.A. Furini, A.L.S. Pereir, P.B. Araujo, Pole placement by coordinated tuning of Power System Stabilizers and FACTS-POD Stabilizers, Int. J. Elec. Power Energ. Syst 3 (3) (2011) 615-622.

[3] Y. Ye, M. Kazerani, V.H. Quintana, Current-source converter based STATCOM: Modeling and control, IEEE Transactions on Power Delivery 20 (2) (2005) 795-800.

[4] Habibur, Fayzur, Harun, Power system stability improvement by using SVC with TID tuned PID controller, IJARCET 1 (8) (2012) 93-98.

[5] http://en.wikipedia.org/wiki/STATCOM.

[6] MATLAB Math Library User's Guide, by the Math Works. Inc..

[7] M.S. El-Moursi, A.M. Sharaf, Novel reactive power controllers for the STATCOM and SSSC, Electric Power Systems Research 76 (4) (2006) 228-241.

[8] M.A. Abido, Analysis and assessment of STATCOM based damping stabilizers for power system stability enhancement, Electric Power Systems Research 73 (2005) 177-185.

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Information and Communication Technologies: A Way to Reduce Digital Illiteracy

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Abstract: The teaching-learning process may have several obstacles; one of those would be a cultural situation of students. When the author refers to cultural situation, the author means the language or dialect that they speak. In the state of Puebla, Mexico, there are primary schools where the courses are taught to students who do not speak Spanish and they only speak their own dialect. On the other hand, the use of information and communication technologies in primary schools in Puebla is a fact but a main concern in schools is that the languages in which they are operated are Spanish. To analyze this situation, the author finds that turns out to be very important and with a negative effect on both the implementation and acceptance of a multimedia program in these schools, generating a technological gap between students. The government efforts are decimated because of this cultural divide prevalent in many communities in the state of Puebla and the increase of this situation when considering the illiterate population.

Key words: Primary schools, information technology, cultural gap and technological gap.

1. Introduction

Various studies have demonstrated the importance and the impact of diverse material resources and equipment of different types [1] to improve efficiency, the learning process and teaching results [2]. According to the Director of United Nations Educational, Scientific and Cultural Organization (UNESCO), Mr. Koichiro Matsura, in his discourse delivered on the 19th of December 2007, "…the information and communication technologies have the power to increase learning access, especially for vulnerable communities in remote areas…", additionally,"…these new technologies can help governments to monitor, manage and apportion educational services in a more efficient way…" he acknowledges information and communication technologies as a basic tool to close the digital divide [3] between cities and countryside, as defined by Inclán [3] as well as between nations.

The basic public educational sector in Mexico is one of the least favored with respect to the use of information technologies, which is unacceptable if the digital divide is to be closed [4]. It is undeniable that in a nation of well-educated citizens there is a profound contribution to the development of a knowledge-based society [5], of a more just and participative society. However, insufficient availability and utilization of information and communication technologies, the low budget increases in educational resources [6] and the inefficient use of available resources [7] are characteristic for the Mexico educational system, which still has not completely manage to appropriate information and communication technologies in spite of the presence of approved programs by the UNESCO as in the case of the Enciclomedia system, the program of Physics Education with Technology and the Program of Mathematics Education with Technology

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whose objective is to incorporate the use of information and communication technologies in the teaching of physics and mathematics in secondary public schools.

This paper will try to portrait the current situation in Pueblas primary school system with respect to the inclusion and use of the information and communication technologies as an educational tool in teaching and learning process, especially the use of the Enciclomedia system in the 5th and 6th grades of primary schools since very few publications have touched on the problem and have seldom taken it into consideration as a factor in educational quality improvement. Consequently, there has been negative impact on productive tasks and the creation of new forms of social interaction in Mexico which could be the foundation of understanding the importance which information and communication technologies has in today´s education [8].

The initial step of this paper is to offer an exploration of the operation of the Mexico educational system, thereafter information related to the Enciclomedia program, the equipping of classrooms for the 5th and 6th primary grades between the 217 counties of the State of Puebla with this tool will be presented. Several models will be developed with the objective of analyzing the impact of the number of systems in relation to the localization of primary schools, according to total Indian population per county and per school modality, dialect spoken and illiterate population. Finally, conclusions will be offered.

2. Literature Review

The Mexico educational system is based on the General Educational Law which, in turn, is based upon Article 3 of the Mexican Constitution. In it are established the general provisions, organization and general structure of the Mexico educational system. In the institutional framework are basic education, middle schools and higher education, each with its different levels and modalities.

In primary education, three modalities are recognized: the General Primary School (urban and rural), the Indigenous Primary School and the Community Primary School. Primary education consists of a 6 year cycle and is obligatory for all Mexicans. For purposes of this paper, general state, federal state, indigenous and indigenous shelter schools in the 217 counties of the state of Puebla will be dealt with.

During the school year 2005-2006, approximately 32 million students were enrolled in the Mexico School System in all of its different levels, types and modalities in 230,000 education centers. The largest number of students, nearly 25 million, is enrolled in basic education (secondary and primary schools) this also includes secondary schools for the working population. This level represents 80.4% of total student enrolment in 92.3% of the school installations (214,394).

14,548,194 students were enrolled in primary education (13,371,543 in public schools and 1,176,651 in private schools) in 98,045 schools (90,896 public schools and 7,149 private schools). 5,979,256 students were enrolled in the secondary education system, (5,531,111 in public schools and 448,145 in private schools) in a total of 31,667 schools (28,246 public and 3,766 private). At the high school level a total of 3,658,754 students (2,924,529 in public schools and 743,225 in private schools) attended 12,841 schools (7,590 public and 5,257 private).

The efforts to create wide infrastructure coverage at the different education levels have been impressive but still not sufficient during various federal administrative periods [9]. For example, 90% of the recourses destined for the education sector in 2006 were for current operation costs and only the small remainder went forward investment and innovation.

Various studies offer information with respect to the impact of the quantity and quality of educational recourses used [10]. In this context, in a study covering the year 2004 education inequalities in Mexico [11], it is pointed out that the use of some inputs are related with the yield, as was the case of the use of computers

in Spanish and mathematics courses where the impact was positive.

In Mexico's National Development Plan for 2007-2012, it is acknowledged as well that there are still lags in the educational system such as the lack of opportunities to access to quality education as well as in advances in technology and information. Therefore, the Plan establishes a collection of objectives and strategies to foment development. Objective number nine: "Elevating the quality of education postulates a series of considerations to achieve this objective which is designed to comply with a combination of strategies". Strategy 9.3 recognizes that educational methodologies must adapt themselves to a changing world to assure the integration of knowledge through new information technologies. Respectively, strategy 9.4, objective 10 and strategy 10.1 describe the importance of the apportionment of resources in an efficient and equitable manner (through our model we will demonstrate that the apportionment of resources in the State of Puebla for equipping classrooms with the Enciclomedia system is done differently) to reduce regional inequalities, modernizing and broadening educational infrastructure.

The stated objective of the National Development Plan recognizes the necessity of spurring development and utilization of new technologies in the educational system to permit the integration of the students into the knowledge society. Therefore, strategy 11.1 has been designed specifically to reinforce the use of new technologies in the teaching process and in the development of abilities in the use of information and communication technologies starting at the basic education level.

In this same context, the State Plan for the Development of the State of Puebla 2005-2011 recognizes the necessity to broaden educational infrastructure to guarantee equal opportunity of access to and continuance in the system for all Puebla citizens. Consequently, at the administrative level, effective deconcentration is fundamental in establishing an integral administrative modernization program which contemplates efficiency in planning structure and the operation of the department. In the diagnosis of the primary educational level, it was established that deteriorating infrastructure still prevails and that there is scarcity of resources.

For its part, the National Institute for the Evaluation of Education (INEE), an organization created in Mexico for the evaluation of quality in the Mexico educational system has conducted various studies [24-27], which reveal the state of school resources available in the matter of information and communication technologies for primary and secondary schools, plus physical space, teaching aids (which includes the availability of computer science teachers) the number of computers and/or other electronic devices, study programs and financial resources.

In the context of the above, we acknowledge that the current educational policy of the Mexican government has evolved, passing from being an indicator of social welfare to being a product adapted to serving that, which determines the new political and economic order [12]. As shown, the technological revolution is an element that has obliged nations to adapt their public policies [13], in light of this factor and educational policy [14] it cannot and must not be disregarded in a context that the educational context has changed [15]. The democratization of education, for its part, appears to be part of the objective of the new economic policy with the eagerness to reduce social inequalities by bringing education to all corners of nation [16].

Emphasizing just how much attention must be paid to the incorporation of information and communication technologies in education, various programs of Mexico´s federal government (Ernesto Zedillo, Vicente Fox and Felipe Calderón) have acknowledged its importance and consequently programs like Enciclomedia (during the administration of Vicente Fox) were created for basic education. That is to say, the investment which the government must make in

order to adopt new information technologies in the educational sector is essential [13] and not to be delayed [17]. The assignment of this resource must be done in such a way, that it does not contribute to the broadening of social inequalities. In that, special care must be taken in deciding which order and how the government will employ this resource and where it will come from [16].

The focus of this paper is the primary school and the incorporation of information and communication technologies through the Enciclomedia program in the classroom. Information and communication technologies have been incorporated in the primary school in different ways around the world as well as in its different levels [18, 19]. Some schools have established laboratories and/or computer rooms, multi-media rooms and/or audiovisual rooms, computers and/or audiovisual equipment in the classrooms [20] with the intent to have equipment which could help the educational community to develop abilities to compete in the marketplace and have better working conditions in the future [16] but, people might choose not to use them for reasons other than the lack of technological skills [21]. Therefore, the digital divide can also be expressed in terms of the abilities needed to take advantage of the information and communication technologies [22] such as the use of English language as the most common used in the internet. In this sense, there are countries that the official spoken language is not English but dialects are or something between an official language and dialects.

In the same way, information and communication technologies will reduce digital illiteracy if population is provided with more technological equipment linked to education [29].

Enciclomedia is an educational strategy, which originated in 1998 and consists of a system of articulated resources which, through digitalization of textbooks and the incorporation of various multimedia resources like videos, photos, maps, graphs, encyclopedias [3] and electronic blackboards [18]. Enciclomedia has linked its lessons in order to contribute to the qualitative improvement of education in public schools in Mexico and is now totally linked to fulfill the educational objectives. It is an innovative way of using technology in the school and thereby can contribute to overcome current issues in education in Mexico. For example, teachers can consult ENCARTA to dispel any doubts that may have arisen among the students during class or the teachers can flesh out the information they are imparting to the students about pre-hispanic cultures with videos of the principal archaeological zones, students can also find interactive excercises on mathematics among others.

The gradual incorporation of information and communication technologies into the classroom, the modernization of pedagogical practice, the production of new educational materials are characteristic of this system.

Enciclomedia began to be used in classrooms of the 5th and 6th grades of primary schools of the 2003-2004 schoolyear and has still not reached its end. At present, it consists of two stages: in the first stage (school year 2004-2005) 21,434 electronic blackboards were installed in classrooms in 7,211 schools as well as in 548 teacher training centers. 670,062 students in the general primary system, 15,649 in the indigenous primary system and about 25,000 teachers have benefitted from the Enciclomedia system. In its 2nd phase, school years 2005-2007, 150,000 electronic blackboards have been installed in the same number of schoolrooms in Mexico [23].

3. Objectives, Variables, Hypothesis and Data

3.1 Objectives

Some factors affect the broadening of the digital gap in developing countries. One of those factors is the way in which educational resources are distributed in public schools but also the social access. The objective of this paper is to analyze the relationship between the equipping of classrooms with Enciclomedia in public primary schools in the State of Puebla and its

geographic location, its modality, the size and type of Indian population in every county in the state of Puebla and illiterate population.

3.2 Variables

3.2.1 Numeq (number of classrooms equipped with Enciclomedia)

Numeq has been selected as a dependent variable relative to the number of classrooms of the 5th and 6th grades of Primary Schools in the State of Puebla equipped with Enciclomedia. The independent variables in their different modalities that will be considered are:

3.2.2 Primest (State Primary School)

This variable refers to the State Primary modality in the State of Puebla. It is a dummy type of variable because the presence of the State Primary in the database is expressed with a 1 and the other modalities with a 0.

3.2.3 Primfed (Federal Primary School)

This variable refers to the Federal Primary modality in the State of Puebla. It is a dummy type of variable because the existence of Federal Primary in the database is expressed with a 1 and the other modalities with a 0.

3.2.4 Primindi (Indigenous Primary School)

This variable refers to the Indigenous Primary modality in the State of Puebla. It is a dummy type of variable because the existence of the Indigenous Primary in the database is expressed with a 1 and the other modalities with a 0.

3.2.5 Dist (Distance in km. Between the City of Puebla and the surroundings counties)

This variable refers to the existing distance in kilometers between the Capital City of the State Puebla and its counties.

3.2.6 Habindi (Indian Inhabitants)

This variable refers to the total of Indian inhabitants for all the municipalities of the State of Puebla.

3.2.7 Numdial (number of dialects spoken in State of Puebla)

This variable refers to the total number of dialects spoken in all the municipalities of the State of Puebla.

3.2.8 Popanalf (Number of inhabitants with the characteristic of illiterating)

This variable refers to the number of people who do not read or write.

3.3 Hypothesis

H_1 = The number of Enciclomedia sets depends on the distance between the capital city of Puebla State and the municipalities.

H_2 = The number of Enciclomedia sets depends on the total of Indian inhabitants for all the counties of the State of Puebla.

H_3 = The number of Enciclomedia sets depend on the distance, Indian inhabitants, federal primary school, state primary school and indigenous primary school.

H_4 = The number of Enciclomedia sets depend on the number of dialects spoken in the State of Puebla.

H_5 = The number of Enciclomedia sets depend on the illiterate population in the State of Puebla.

H_6 = The number of Enciclomedia sets depend on the distance and the illiterate population in the State of Puebla.

3.4 Data

The State Coordination of Distance Education of the Ministry of Public Education of the State of Puebla in Mexico (CETE-SEP) provided us with a database which contained the following information of the State of Puebla: County name and its localities (these data had to be verified individually to correct errors with respect to names and number of localities referred to), the number of classrooms equipped with Enciclomedia in the fifth and sixth grades of Primary School (2,532 school rooms is the total of the sample), school modality (Federal Primary, State Primary, Indigenous Primary).

Herby item, this database displays 3 levels of Enciclomedia classroom equipment. The two first levels contain the information of equipment in Enciclomedia classrooms for fifth and sixth grades of Primary School in different stages (I and II) and the third level (III) has information of equipment for the first grade of

secondary. In this paper, only level II of equipment for fifth and sixth grades of Primary School for the years 2005 and 2006 will be dealt with.

Added to the database mentioned above, are four more variables. The first variable is the distance in kilometers existing between the capital of the State of Puebla and the 216 counties in the rest of the State, the second variable is the number of Indian inhabitants in each county of the State of Puebla, the third variable is the number of dialects spoken in the State of Puebla. The dialects are: Náhuatl, totonaco, mixteco, mazateco, zapoteco, popolaca, chocho, otomí, tlapaneco and tepehua. The fourth variable is related to illiterate population.

4. Descriptive Statistics

4.1 Research Variables

Table 1 shows descriptive statistics for the research variables used in this paper. The number of observations is 217 that correspond to the total number of municipalities. The maximum classrooms equipped with Enciclomedia systems are 650 and the mean corresponds to 27.68 Enciclomedia sets per county. The major distance from the City of Puebla is 300 km. the average of distance is 120.27 km. The maximum Indian inhabitants in one municipality are 47,199. The mean of Indian inhabitants in all counties is 2,772 and the standard deviation is 5,591. The mean for the illiterate population is 1,876 and the maximum number for illiterate people in the state of Puebla is 38,351.

4.2 School Modality

Table 2 shows the descriptive statistic for the school modality variables used in this work. The average of state primary schools equipped with Enciclomedia sets per county is 2.36 while in the federal primary schools are 6.51. Finally, there are more federal primary schools than state primary schools or indigenous primary schools.

4.3 Dialects Spoken

Table 3 shows the percentages for each dialect spoken in the State of Puebla. The most spoken dialect is Nahuatl as shown in the table. The less spoken dialect spoken is Tepehua.

Table 1 Escriptive statistics for variables.

Variable	Mean	Std. Dev.	Min	Max
numeq	27.68	48.81	1	650
dist	120.27	66.04	1	300
habindi	2,772	5,591	0	47,199
popanalf	1,876	3,092	47	38,351

Table 2 Escriptive statistic for modality.

Variable	Mean	Std. Dev.	Min	Max
primest	2.36	4.85	0	66
primfed	6.51	8.39	0	78
primin	2.61	5.34	0	38

Table 3 Ialects spoken in the State of Puebla.

Dialect	Percentage	Dialect	Percentage
náhuatl	62.42%	popoloca	2.68%
totonaco	16.44%	zapoteco	2.01%
mixteco	8.39%	Chocho	0.67%
otomí	3.36%	tlapaneco	0.67%
mazateco	3.02%	tepehua	0.34%

5. Models, Methodology and Results

5.1 Models

The following equations are the proposal models to prove the hypotheses postulated earlier:

$$\text{Model } H_1 \qquad \text{numeq} = \beta_0 + \beta_1 \text{dist} \tag{1}$$

$$\text{Model } H_2 \qquad \text{numeq} = \beta_0 + \beta_1 \text{habindi} \tag{2}$$

$$\text{Model H} \qquad \begin{aligned} \text{numeq} &= \beta_0 + \beta_1 \text{dist} + \beta_2 \text{habindi} + \\ &\beta_3 \text{primest} + \beta_4 \text{primfed} + \beta_5 \text{pri min di} \end{aligned} \tag{3}$$

$$\text{Model } H_4 \qquad \text{numeq} = \beta_0 + \beta_1 \text{numdial} \tag{4}$$

$$\text{Model } H_5 \qquad \text{numeq} = \beta_0 + \beta_1 \text{popanalf} \tag{5}$$

$$\text{Model } H_6 \qquad \text{numeq} = \beta_0 + \beta_1 \text{dist} + \beta_2 \text{popanalf} \tag{6}$$

5.2 Methodology

The methodology that we follow is with a linear regression by ordinary least squares was utilized in such form as to permit arriving at the relationships.

5.3 Results

5.3.1 Hypothesis 1

In Table A1, there is a relationship between the

number of Enciclomedia sets and the distance between Puebla City and the remaining municipalities. The furthest (300 km far away from Puebla City) the less primary school equipped with the Enciclomedia system.

5.3.2 Hypothesis 2

In Table A2, we can demonstrate that the municipalities with more inhabitants deserve more equipped classrooms with Enciclomedia system.

5.3.3 Hypothesis 3

The number of Enciclomedia sets is related to the distance, the number of Indian inhabitants and the school modality (Table A3).

5.3.4 Hypothesis 4

In Table A4, we can demonstrate that the municipalities with most spoken dialect deserve more Enciclomedia sets.

5.3.5 Hypothesis 5

In Table A5, we can demonstrate that the municipalities with most illiterate population deserve more Enciclomedia sets.

5.3.6 Hypothesis 6

In Table A6, we can demonstrate that the municipalities which are 300km far away from Puebla City are less equipped with the Enciclomedia sets and municipalities with most illiterate population deserve more Enciclomedia sets.

6. Conclusions

The National Development Action Plan of México has included within its action initiatives, the incorporation and use of information and communication technologies in the education sector, particularly for the basic education, with the proposal of introducing the student to the Knowledge society. In Table 2, it can be seen that there are a larger number of Federal Primary Schools equipped with Enciclomedia in the State of Puebla with 78, while in the Puebla State Plan for Development no mention is made of information and communication technology in the education sector and it can be seen that only 66 State Primary Schools are equipped with Enciclomedia. As Stiglitz [20] has indicated, the assignation of this resource must be made in such a way as to not contribute to the widening of the social inequalities, wherefore special care must be taken in deciding which order the government apply this resource, as well as from which sources it will come, so that the way in which this resource is distributed to primary schools in the State of Puebla does not contribute to the broadening of the digital gap between Federal Primary Schools and State Primary Schools.

It can be said in Table A1, that the farther away any of the 216 municipalities are from the State Capital, the lower the number of Primary Schools with Enciclomedia equipment, this point is particularly important for decision makers in so far as in equipping classrooms with Enciclomedia [28], without regard as to what might be the motive for why the most distant Primary Schools are less equipped, the end result is that these areas have less access to information and communication technology, and from that we can conclude the State Plan for Development in Education and the National Plan for Development in Education are not pursuing the same objective, at least in the incorporation of information and communication technology in Primary Schools. In Table A2, we show that the number of Indian inhabitants with respect to the number of equipment sets has a positive relationship, this means that a major number of Indian inhabitants the government provides more Enciclomedia sets for that kind of population. But at the same time, government realizes that municipalities with more Indian population should have more Enciclomedia sets.

On the other hand, the municipalities with more than two spoken dialects are the most favored with Enciclomedia sets, in order to reduce the cultural and technological gap.

Finally, we can assume that if population in Puebla is less equipped with Enciclomedia sets, then the government contributes to digital illiteracy.

References

[1] G.R. Cuellar, La calidad de la educación básica en México, Capítulo 3, Docentes, Infraestructura y equipamiento de las escuelas, México INEE, 2006, p. 117.

[2] T. Fernández, I. Banegas, E. Blanco, Sistema de Cuestionarios de Contexto INEE 2005-2008, Fundamentos teóricos de los conceptos propuestos a ser observados en los módulos permanentes del Sistema de Cuestionarios de Contexto para el ciclo de evaluaciones 2005-2008, México: INEE, 2004.

[3] F. Reimers, Aprender más y mejor, Fondo de Cultura Económica, Mexico, 2006.

[4] Ph. Quéau, Governing the Global Knowledge Society, citado en "Desarrollo de la Sociedad de la Información en América Latina y el Caribe", Menezes, Claudio, Consejero Regional, División de la Sociedad de la Información, UNESCO-Montevideo.

[5] J. Vilaseca, La economía del conocimiento: Paradigma tecnológico y cambio estructural. Working Paper Series WP02-003, UOC, 2002.

[6] O. Cárdenas, El gasto educativo: una propuesta de financiamiento a la educación básica, Volumen XVI, Número 2. II Semestre de 2007, Gestión y Política Pública.

[7] T. Bracho, Perfil nacional encargado para el Informe de Seguimiento de la EPT en el mundo 2008, Educación para Todos en 2015-¿Alcanzaremos la meta? México, Estudio de Caso, UNESCO, 2007.

[8] J.C. Botello, Las tics y el sistema educativo mexicano, Congreso Internacional de Investigación en Ciencias Administrativas, Tijuana, México, 2008.

[9] A. Alcántara, 25 años de políticas educativas en México, IISUE-UNAM, 2006.

[10] S. Schmelkes, La calidad de la educación primaria: Un estudio de caso, México: Fondo de Cultura Económica, 1997.

[11] E. Treviño, G.y Treviño, Estudio sobre las desigualdades educativas en México: La incidencia de la escuela en el desempeño académico de los alumnos y el rol de los docentes, Colección Cuadernos de Investigación México: INEE, 2004.

[12] Infraestructura Escolar en las Primarias y Secundarias de México, México: INEE, 2007.

[13] Panorama Educativo de México 2007, México: INEE, 2007)

[14] La calidad de la Educación Básica en México 2006, México: INEE, 2006).

[15] Instituto Nacional para la evaluación de la educación. Artículo: El estado que guardan nuestras escuelas, Fundación Este País, México: INEE, 2007.

[16] M.V. Cruz, Modernización Educativa o Reconstrucción de la legitimidad del Estado en México, Papeles de Población, abril-junio, número 020, Universidad Autónoma del Estado de México, 1999.

[17] A. Carty, P. Phelan, The nature and provision of technology education in Ireland, Journal of Technology Education 18 (1) (2006).

[18] S.C.Y. Shelley, A study of uses of ICT in Primary Education through Four Winning School cases in the Taiwan schools cyberfair, Educational Technology & Society, IEEE Computer Society 11 (3) (2008) 52-66.

[19] J. Tejada Fernández, La educación en el marco de una sociedad global: algunos principios y nuevas exigencias. Profesorado, Revista de currículo y formación de profesores, Año/vol 4, Universidad de Granada, Granada, España, 2000.

[20] J. E. Stiglitz, Economics of the Public Sector, 2000.

[21] J.C.Y. Lam, M.K.O. Lee, Digital inclusiveness-longitudinal study of internet adoption by older adults, Journal of Management Information Systems 22 (4) (2006) 177-206

[22] E. Huerta, E. Sandoval-Almazan, Digital literacy: Problems faced by telecenter users in Mexico, Journal of Information Technology for Development 13 (3) (2007) 217-232.

[23] E. Andere, ¿Cómo es la mejor educación en el mundo? Políticas educativas y escuelas en 19 países, Ed. Santillana, 2007.

[24] J. Jenson, Finding space for technology: pedagogical observations on the organization of computers school environments, Canadian Journal of Learning and Technology 32 (1) (2006) 35.

[25] D. Passey, Technology enhancing learning: Analysing uses of information and communication technologies by primary and secondary schools pupils with learning frameworks, The Curriculum Journal 17 (2) (2006) 139-166.

[26] Q.Y. Wang, H.L. Woo, Systematic planning for ICT integration in topic learning, Educational Technology & Society 10 (1) (2007) 148-156.

[27] Información estadística de Enciclomedia [Online], Extraída el 28 de Enero de 2008, desde, http://www.enciclomedia.edu.mx/Conoce_Enciclomedia/Numeralia.htm.

[28] J.C. Botello, M. Dfivila, Equipping the public primary schools in Puebla: The case of the Enciclomedia system in the State of Puebla, Mexico, Journal of Computer Technology and Application 3 (10) (2012) 668-677.

[29] R. Aderinoye, Literacy and communication technologies: distance education strategies for literacy delivery, International Review of Education 54 (2008) 605-626.

Appendix

Table A1 Stata's results for model 1.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
dist	-0.080403	0.0501123	-1.6	0.11	-0.1791773	0.0183713
_cons	37.34764	6.872129	5.43	0	23.80227	50.89301

Table A2 Stata's results for model 2.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
habindi	0.0058843	0.0004398	13.38	0	0.0050173	0.0067512
_cons	11.36197	2.739836	4.15	0	5.96159	16.76235

Table A3 Stata's results for model 3.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
dist	-0.0640675	0.0118168	-5.42	0	-0.0873616	-0.0407734
habindi	0.0015753	0.0002016	7.81	0	0.0011778	0.0019727
primest	5.233161	0.2128716	24.58	0	4.813534	5.652789
primfed	2.278273	0.1175275	19.39	0	2.046595	2.509952
primindi	0.8925403	0.1830616	4.88	0	0.5316763	1.253404
_cons	1.515214	1.682382	0.9	0.369	-1.801216	4.831645

Table A4 Stata's results for model 4.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
numdial	15.42128	5.638245	2.74	0.007	4.307964	26.53459
_cons	6.49981	8.403063	0.77	0.44	-10.06312	23.06274

Table A5 Stata's results for model 5.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
popanalf	0.0151379	0.0003049	49.65	0.000	0.0145369	0.157389
_cons	-0.7273661	1.101028	-0.66	0.510	-2.897558	1.442825

Table A6 Stata's results for model 6.

numeq	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
dist	-0.0453255	0.0139905	-3.24	0.001	-0.0729024	-0.0177486
popanalf	0.0150898	0.0002988	50.51	0.000	0.014501	0.156787
_cons	4.8144169	2.021579	2.38	0.018	0.8294116	8.798926

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The Practical Design Aspects of Anti-aliasing Filters for the Multirate Analog-to-digital Processing in Microcontroller Embedded System

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Abstract: Due to the widespread computer technology, it is difficult to imagine a research or a control of any physical object without using a powerful hardware and software applications. To use digital technologies we need to collect data of a real world in digital system by the analog-to-digital converters. Taking into account the relative high computational capabilities of modern microcontrollers, the article proposes a multirate processing system. The paper presents practical design aspects of the analog and digital anti-aliasing filter for the measurement path, having regarded the real possibilities and limitations of today's filters and analog-to-digital embedded converters.

Key words: ADC, signal acquisition and multirate filtering.

1. Introduction

Practical experience shows that it is difficult to construct good quality high order analog filters. Due to limited number of nominal values offered by the passive components manufacturers and poor passive components precision, most filters do not exceed six poles design. In multirate processing implementation satisfying results can be achieved with a low order analog filter. Multirate filtering technique relies on high rate oversampling of an analog signal with Analog to Digital Converter (ADC) and afterward filtering to the required band with a high fidelity low pas digital filter. Unlike in conventional anti-aliasing circuit, here the dumping of amplitude at half of ADC sampling frequency could be much smaller—what additionally reduces the order of required anti-alias analog filter. This situation is illustrated at Fig. 1.

At the beginning of multirat process shown in Fig. 2 there is a need for conditioning of the input signal to maximum range of amplitude and frequency, which can be correctly converted by ADC.

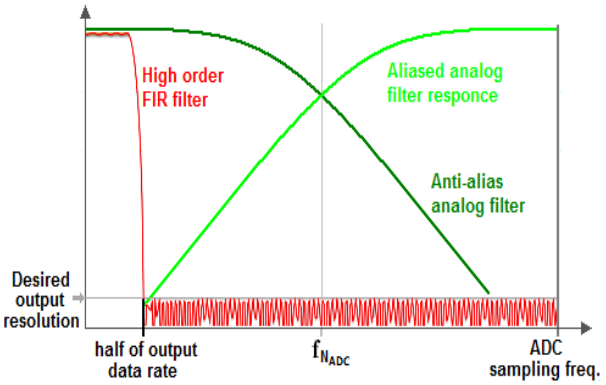

Fig. 1 Example of proper tuned filters.

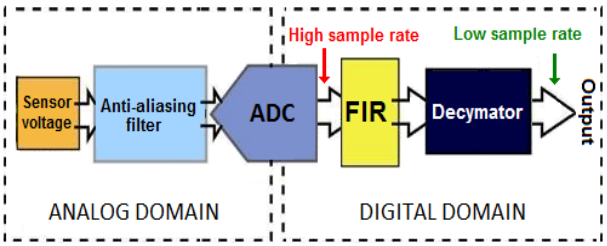

Fig. 2 Multirate analog-to-digital processing chain.

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Namely, the signal should gain the amplitude that provides the maximum signal resolution without clamping, with the bandwidth reduced in order to keep distortion derived from aliasing occurrence to final (digital) output to a negligible level. An Analog-to-digital converter samples the input signal much more frequently than required rate for a designed bandwidth at output data (oversampling). Thanks to much better properties of digital filters (if compared to analogues), the bandwidth of output data is limited with digital precision by the Finite Impulse Response (FIR) filter. Due to the fact that the signal is filtered after the addition of quantization noise in the analog to digital conversion process, the output signal resolution will be improved. Finally, the filtered signal data rate is matched to the resulting bandwidth in the decimation process. Therefore, the obtained signal has excellent properties for further processing.

2. Challenges during Analog-to-digital Multirate Processing Design

Efficient design always required a lot of experience and knowledge, each case is different and requires an individual approach, especially when we are looking for an improvement in order to achieve the highest quality. The key issue for good designing is to understand each part of the processing chain, and its influence on the final results.

2.1 Analog Anti-aliasing Filter Tuning

The high oversampling ratio reduces required analog filter order, however due to a low source impedance requirement for proper ADC conversion [1], there is a necessity of using at least one operational amplifier. In non-inverting applications third order Sallen-Key topology [2] shown on Fig. 3 could be good option due to its low cost versus pole count.

Presented analog filter solution requires careful component selections. In single supply circuit best option will be the rail-to-rail CMOS operational amplifier which will ensure low inputs bias currents [3].

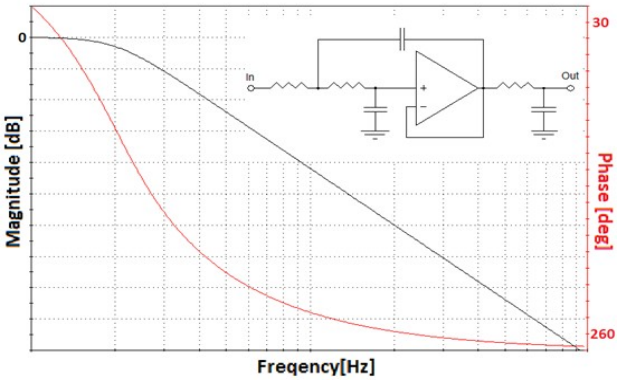

Fig. 3 Third order low-pas filter topology.

In view of non-zero real sensor output impedance, high resistors values at non inverting inputs are desirable, on the other hand this resistance values should not be too high—to avoid noise generation above ADC resolution level.

In proportional regulator circuits (like operational amplifier) a control error is proportional to the loop gain (forward gain of amplifier and feedback gain)—consequently in order to achieve irrelevant output voltage error—the approximate Gain Bandwidth Product (GBP) requirement for amplifier used in analog filter is as follows:

$$GBP \geq 2^{ENOB_{out}} \cdot G \cdot BW_{out} \qquad (1)$$

where, $ENOB_{out}$—effective number of bits at output, G—closed loop DC gain, BW_{out}—final (decimated) signal bandwidth.

This condition is hard to satisfy at higher resolution and bandwidth assumptions, therefore designer need to optimize costs of amplifier IC and system performance.

Similarly, amplifiers slew rate should provide output voltage swing in range of ADC input, at time corresponding to desired output bandwidth.

The RC filter at operational amplifier output should be also tuned to provide stability. On the one sight, a high capacitance at the ADC input is desired, but driving high capacitive loads tend to have oscillation problem when RC values are improperly selected [4].

In phase-sensitive applications it is recommended to keep desired output band pass in possible linear part of analog filter phase response characteristic—by using

higher cut-off frequency.

As presented in Figs. 3 and Fig. 4, to avoid ADC clamping and aliasing effects in output (decimated) signal, analog filter transfer function should fulfill this inequality:

$$\left|T\left(f_s-\frac{f_{out}}{2}\right)\right|<\frac{1}{2^{ENOB_{out}}} \quad (2)$$

Where, f_s —ADC sampling frequency, f_{out} —output (decimated) samples rate, $ENOB_{out}$ —effective number of bits at output.

2.2 Analog-to-digital Converter

Microcontrollers embedded ADCs, do not offer excellent parameters however, they are the best-choice in cost and/or surface sensitive applications. Moreover, they often offer an expanded triggering and Direct Memory Access (DMA) efficient capabilities. Table 1 compares key parameters of ADC peripheral used in most popular, modern, 32-bit microcontrollers. It's worth to mention a greater importance of resolution over sampling-rate. Achieving every single bits of resolution requires a four times higher sampling frequency.

2.3 Digital FIR Filter Tuning

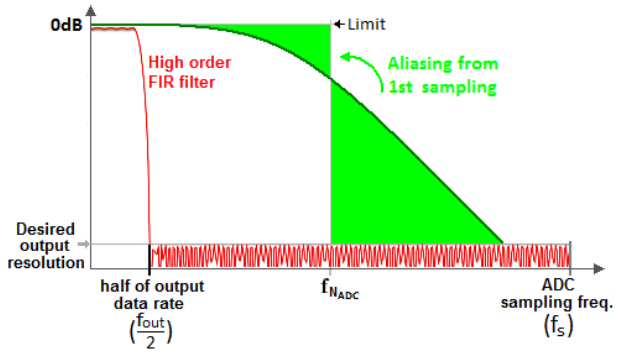

Fig. 4 Maximum aliasing limit in proper tuned path.

Table 1 Key param. of modern, most popular MCUs ADC.

IC Manufacturer, device family	ADC resolution	Max. ADC sampling rate
Atmel, AT32UC3C	12bits	1.2 Msps
Freescale, MCF32	12bits	0.8 Msps
Microchip, PIC32MX	10bits	1 Msps
NXP, LPC4	10bits	0.4 Msps
STM, STM32F4	12bits	2 Msps

The Digital FIR filter is a key component of the whole system, and it should be used to get all the desired properties of amplitude and phase. Because of its high order, FIR has much more significant influence on the system. It should be as precipitous as possible. The cut-off frequency needs to be setup for achieving the damping level that corresponds with an output effective resolution, at frequency of half output (decimated) data rate. The number of FIR taps should be higher or even to the oversampling ratio, generally it's much higher. In embedded systems, computing efficiency could be increased by using DMA for ADC buffer filing/copying and algorithm presented on Fig. 5. In that case the length of FIR core should be an integer multiple of oversampling ratio. Maximum number of tabs is limited by the available computing power and by capabilities of used FIR CAD software. Standard Remez Exchange Algorithm based software does not work properly with more than four or five hundred tabs. Keep in mind that in most applications there are much more important tasks than ADC processing. Modern MCUs need approximate 10 MIPS to calculate 8 kHz sample rate, three hundred tabs, 16-bit precision, highly optimized, FIR code [5, 6].

In many cases using a digital filter, not only for anti-aliasing purposes, but also as filter for application aims or for signal conditioning (e.g. mains frequency hum deleting) is good optimization.

Important convenience during digital filter designing

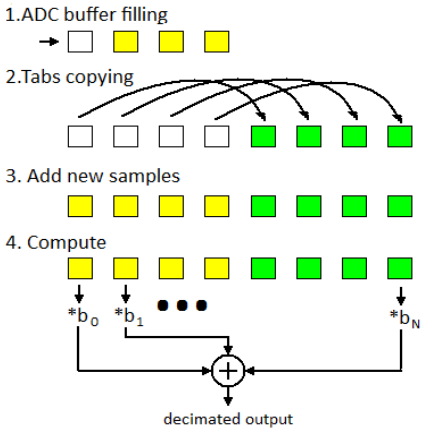

Fig. 5 Optimum FIR filtering and decimating algorithm.

easily access to many well developed FIR design software.

2.4 Achieving Higher Output Resolution Using Oversampling

Thanks to use FIR filters on previously sampled signal, we are able to reduce quantization noise causing improvement in signal accuracy [7]. Required oversampling ratio versus achieving bits of accuracy is shown by the equation:

$$OVSR = 10^{(0.602 N_{ab})} \tag{3}$$

where, *OVSR*—oversampling ratio, N_{ab}—number of achieved bits.

2.5 Decimation

Filtered signal does not contain useful information in bandwidth above the cut-off frequency. Therefore, signal sampling frequency should be decreased to double frequency of stop-band beginning. Non-synchronous decimation is a complex operation so, if is it possible, ADC sampling frequency should be an integer multiple of desire output frequency—that ensures synchronous decimation and allows to use algorithm presented on Fig. 5.

3. Designing Procedure

First step in every designing process is defining system needs and available resources, and then proposed designing procedure could be many times repeated (in both way—forward and reverse) while finding the acceptable solution. When ADC is selected (ADC sampling rate and resolution is known) the second step will be digital filter designing. FIR designing often takes most effort and time. Last step is analog filter designing.

4. Conclusions

The paper is a composite introduction to understanding multirate analog-to-digital processing in embedded system. It contained knowledge will be also useful for all kind measurement systems using multirate processing with Data Acquisition (DAQ) cards. It shows sense of each conversion block, and treats about major issues that might be encountered during designing process.

References

[1] S.W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing [Online], 2nd Ed., California Technical Publishing, San Diego, California, www.dspguide.com.

[2] R.G. Lyons, Understanding Digital Signal Processing, 3rd Ed., Prentice Hall, 2010.

[3] J.M. Madapura, Achieving Higher ADC Resolution Using Oversampling [Online], AN1152, Microchip Technology Inc., www.microchip.com.

[4] P. Harpe, H. Heght, A.H.M. van Roermund, Smart AD and DA Conversion, Analog Circuits and Signal Processing (2010) 19-40.

[5] F. Maloberti, DataConverters, Springer US.

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Evaluation of the Websites of Logistics Operators by Customers

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Abstract: In this article, the results were presented of research concerning the visual and functional aspects of the websites of three largest logistics operators in Poland. The research was carried out with the participation of the following three groups: institutional customers, individual customers and marketing management students. The article covers an attempt to evaluate cooperation through virtual contacts with the company. The analysis also concerned such issues as information on corporate social responsibility (CSR), information on job offers and the position of the company on the market.

Key words: Logistics operator, website, institutional customer, individual customer, information system.

1. Introduction

In the era of information society, it is the Internet that exerts an influence on the image of the present-day business. The significance of this information and communication medium is systematically increasing. In the year 2012, computers were used in 95% of companies including almost all large entities. 93% of all companies in Poland had an Internet access. The greatest increase in the annual scale (by 4.7 percentage points) was observed as regards access to narrowband wireless connections; in spite of this, companies most frequently used broadband connections (82%). In the year 2012, 41% of companies declared that they equip their employees with devices that enable mobile Internet access. The percentage of those employees who use computers is systematically increasing (up to the level of 43% in the year 2012). A significant regional diversification of this index is observed, yet the companies examined from Zachodniopomorskie Province possess similar access as in the remaining parts of the country, i.e. 93.1% (for Poland in the year 2012: 93.2%). In the year 2012, the index of those companies that possess their own websites increased in the annual scale. The greatest increase (by 3.2 percentage points) was observed in the case of small companies. Over 50% of companies used a website to present their catalogues of products and services. In the year 2011, almost one fifth of companies submitted orders via a computer network, and every tenth company received an order by the Internet. In the year 2011, 90% of companies used e-administration, while almost all large companies and 97% of medium sized companies in Poland used this form of contact with public administration [1]. The purpose of the article is to present an evaluation of the websites of logistics operators and of information obtained from these websites. The methods applied in the study include the method of indirect survey measurements with the application of the questionnaire form technique and a comparative analysis of selected customer groups. The paper is organized as follow: Section 2 presents the research results: visual evaluation of the websites of operators; Section 3 is on the evaluation provided by institutional customers of cooperation by means of the websites of logistics operators; Section 4 gives the

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evaluation of the cooperation of individual customers with the logistics operator based on websites; Section 5 discusses the result and discussion; Section 6 is conclusions.

2. Presentation of Research Results: Visual Evaluation of the Websites of Operators

The research covered the websites of three logistics operators with the highest incomes in Poland and the greatest growth dynamics: Deutsche Post DHL, Deutsche Bahn Schenker and the Raben Group [2]. The research was carried out in Zachodniopomorskie Province with the participation of three groups: institutional customers, individual customers and marketing management students. The largest group from among institutional customers (150 companies were polled) were the representatives of small companies: 73.33%, medium sized companies: 20% and large companies: 6.67%. The individual customers cover a group of two hundred people, where women accounted for 53% and men account for 47%, in the following age groups: up to 30: 35%, 31-40: 30%, 41-50: 20% and over 50: 15%. A group of thirteen students from the Faculty of Economic Sciences at the Koszalin University of Technology was selected as experts of marketing management: those who are about to complete their third year of bachelor studies, and who use the Internet. The following marking Likerta scale was used: 5—very high, 4—high, 3—average, 2—low, 1—very low, 0—I have no opinion [3, 4].

On the grounds of the indications received, it can be found that the colour schemes of the websites are the most suitable according to institutional customers, while this aspect was ranked the lowest by the group of students, who in 46.16% of cases ranked it as average and 7.69% of cases as very low (see Fig. 1).

Individual customers (5%) expressed no opinion. 20 per cent of the companies ranked the website very high. The credibility of the forwarding companies was assessed as low by the companies (13.33%), and the lowest number of very high marks was given by the students (see Table 1). This is also connected with confidence in the selected logistics operators.

The companies and the individual customers ranked very high the credibility of logistics operators as they cooperate with them, order shipments and collect shipments. In the case of the individual customers, 90% of them provided good and high marks. In spite of the fact that as regards the companies and individual customers, there are low and very low marks in connection with professionalism, it is the students who in 30.77% cases assessed the professionalism of the websites as average (see Table 2). While implementing an IT system, operators need to consider the following objectives [5, 6]:

(1) The company must define which processes are to be computerized (this allows one to predict the scale of the project);

(2) The selected IT company is to advise, cooperate and not to force any solutions, the implementation

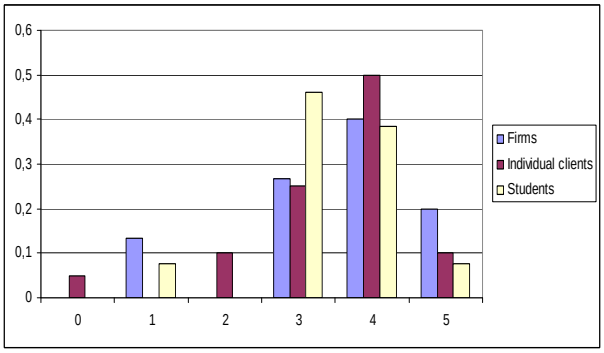

Fig. 1 Evaluation of the colour schemes of websites by the groups examined.

Table 1 Evaluation of the credibility of logistics operators (data in percent).

Credibility	0	1	2	3	4	5
Companies	0	0	13.33	6.67	46.67	33.33
Individual customers	0	0	0	10	65	25
Students	0	0	0	30.77	61.54	7.69

Table 2 Professionalism of the websites of logistics operators (data in percent).

Professionalism	0	1	2	3	4	5
Firms	6.67	0	6.67	6.67	66.66	13.33
Individual clients	0	5	0	10	55	30
Students	0	0	0	30.77	53.85	15.38

company ought to possess experience in the similar areas of previously realized projects (e.g. in courier companies);

(3) An involvement in the project of those who operate the system on daily basis is essential; the user may have valuable observations concerning the facilitation of routine activities;

(4) The information system should be accurately verified with respect to the functionality assumed.

As concerns an analysis of the ease of the exploration of the websites, the greatest number of problems was voiced by the students, while the individual customers expressed the smallest number of problems: 90% gave very high and high marks. The companies provided an average evaluation as regards the ease of the exploration of the websites of the logistics operators examined: 53.33% (Fig. 2).

The replies provided by the companies surveyed indicate that the websites of logistics operators contain up-to-date information: 73.33%. As few as 6.67 per cent of them state that there are no updates. The students assessed the shortage of up-to-date information as low and average (61.54%). Five per cent of the individual customers expressed no opinion on this issue (Table 3).

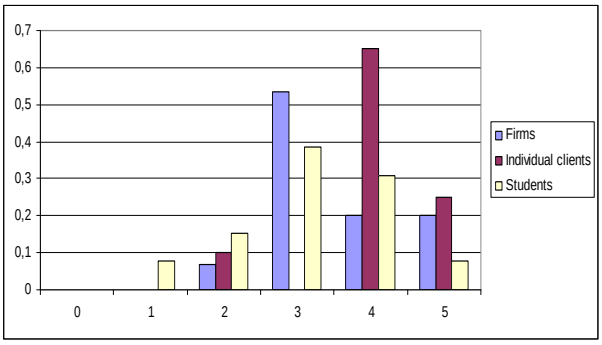

Fig. 2 Ease of the exploration the websites of logistics operators.

Table 3 Validity of information contained in the websites of the logistics operators examine (data in percent).

Timeliness	0	1	2	3	4	5
Firms	0	6.67	0	20	46.66	26.67
Individual customers	5	5	5	20	45	20
Students	0	0	15.38	46.16	23.08	15.38

The individual customers were not interested in the company history because as many as ten per cent assessed it low due to the fact that it was of no interest to them. The institutional customers evaluated highly (40%) the history of the logistics operator, and they specified in the interview how many years they have been cooperating with this operator.

3. Evaluation Provided by Institutional Customers of Cooperation by Means of the Websites of Logistics Operators

Information concerning the place of the consignment is the most important piece of information to those companies that cooperate with a logistics operator. 46.67% of them assessed it very high, and 33.33% assessed it high (Table 4 and Table 5). Information on job offers is of no interest to the representatives of small companies. This information is most frequently sought by the employees of medium and large companies. This also concerns information of corporate social responsibility. Small companies evaluate it as low or average because they are not interested in it. Large and medium companies assess the operator's activities in the sphere of CSR as high or good. Companies voluntarily take into consideration social and eco-friendly aspects in their business activities, and in this way they realize the concept of social responsibility [7]. Corporate social responsibility is an effective strategy of management on the national level, but first of all on the local level. It contributes to a company being distinguished on the market, to an increase of its competitiveness on the global level, while at the same time conditions are created for a sustainable social and economic development [8]. The social responsibility of businesses was defined as an obligation on the part of a company to pursue such a social policy and to take such decisions as are desirable with the objectives and values of society. According to the CSR idea, a company has not only economic and legal obligations but also certain duties in society which go beyond the first two limits mentioned above

Table 4 Evaluation criteria of cooperation with logistics operator by companies (data in percent).

Evaluation criterion	0	1	2	3	4	5
Information on consignment	0	0	6.67	13.33	33.33	46.67
Information on job offers	0	0	20	20	40	20
Information on corporate social responsibility (CSR)	0	0	20	13.33	40	26.67

Table 5 Evaluation criteria of cooperation with logistics operator by companies (data in percent).

Evaluation criterion	0	1	2	3	4	5
Information on cooperation	6.67	0	6.67	13.33	40	33.33
Contact with operator	6.67	0	6.67	6.67	26.66	53.33
Position of company on the market	0	0	6.67	26.67	53.33	13.33

[9]. An efficient and reliable flow of information streams constitutes the basic condition for an effective functioning of a company [10]. Logistics operators opt for those information systems which allow them to very quickly process and analyze a large number of information in order to efficiently monitor physical flows and optimize decision-making processes, and then to make these available on the website of the consignment sender and recipient [11].

Institutional customers rely on sophisticated cooperation with the logistics operator, the best form being via the Internet as they do not have enough time for meetings. Cooperation should be based on the transmission of information; hence there is a high evaluation of virtual contacts with the operator. For small companies, the operator's position on the market is of no importance (all of them assess as high their participation in the market), yet they depend on the quality of services and comfort. Medium sized companies do not take into consideration forwarding companies because they do not meet all the conditions of cooperation, such as storage, customs and international transport.

4. Evaluation of the Cooperation of Individual Customers with the Logistics Operator Based on Websites

80% of the individual customers assess high the possibility to check the shipment path over the Internet. They think that it is a good employer and information on job vacancy is assessed high: 85% (Table 6 and table 7). The individual customers are practically not interested in the operations of logistics operators concerning social responsibility (50%). Cooperation as regards collection and not sending is assessed as good (e-mail from the operator including details on sending and the collection time of the shipment is sufficient information). The possibility of electronic management increases the amount of internet purchases. In the case of the use of information systems with the use of B2C (business to consumer), this is minimized [12].

Information on cooperation with the logistics operator based on websites is scarce because no consignment supplier is indicated in 90%, and as many as 10% of individual customers have no opinion on this issue. 40% of them evaluate as low or average cooperation with companies of this type. Contact over the Internet with the logistics operator is essential for the realization of the correct consignment collection. A high assessment of the position of the company on the market and its participation in the market guarantees the consignment delivery in the appropriate place and time, and for an adequate price.

5. Results and Discussion

Institutional customers need to have an Internet access. Those transformations that are the result of IT

Table 6 Evaluation criteria of cooperation with logistics operator by individual customers (data in percent).

Evaluation criterion	0	1	2	3	4	5
Information on consignment	0	0	10	10	25	55
Information on job offers	0	0	5	10	45	40
Information on corporate social responsibility (CSR)	5	5	15	30	30	15

Table 7 Evaluation criteria of cooperation with logistics operator by individual customers (data in percent).

Evaluation criterion	0	1	2	3	4	5
Information on cooperation	10	0	10	30	40	10
Contact with operator	0	0	0	15	35	50
Position of company on the market	5	0	20	10	20	45

technologies necessitate investments in modern hardware and software. Institutional customers have been cooperating with logistics operators over long periods of time; hence, there are higher requirements, yet there are also lower requirements connected with the visualization of the website. Individual customers are the recipients of consignments, and information concerning the shipment and contact with the operator is of a primary importance. The students constitute a group that is characterized by the greatest critical evaluation of the websites. They pay attention to the issues of the colour schemes and the ease of the exploration of the website as well as professionalism. They express the need of improvements in many aspects.

6. Conclusions

The visualization of the websites of logistics operators serves to confirm the professionalism of a given company. It is related to confidence in the company; hence, the institutional customers ranked these issues the highest. Cooperation with the logistics operators via websites is very highly assessed. All the abovementioned criteria of B2C cooperation via websites are evaluated considerably higher by the individual customers, who are the recipients of consignments but are not interested in the CSR activities of logistics operators. The group of marketing management students accepted a critical approach towards the Internet offer: information on job offers, corporate social responsibility and conditions of cooperation were evaluated as low. The ease of obtaining information on the shipment and the possibilities of contact with the logistics operator was evaluated as high. The efficient flows: not only those of products but also of information, which are ensured by the logistics operator with the use of websites, constitute the basic condition of an effective functioning of the supply and distribution areas. The results obtained demonstrate high awareness concerning the significance of the websites of logistics operators in the realization of B2B (business to business) and B2C logistic processes.

References

[1] http://www.stat.gov.pl/cps/rde/xbcr/gus/nts_spolecz_inform_w_polsce_10-2012.pdf.

[2] H. Brdulak, Polski rynek LTS w 2012 r, Rzeczpospolita, LTS 2 (2013) 22-31.

[3] E. Babbie, Badania społeczne w praktyce, Wyd. PWN, Warszawa 2003, p. 173.

[4] S. Kaczmarczyk, Badania marketingowe. Metody i techniki, Wyd. PWE, Warszawa 2003, pp. 172-129.

[5] P. Fajfer, R. Pawlak, B. Swoboda, Procesowe zarządzanie zintegrowanych systemach informatycznych na podstawie systemu iScala, Wyd. WSL, Poznań 2009, pp. 74-86.

[6] M. Chaberek, A. Jezierski, Informatyczne narzędzie procesów logistycznych, Wyd. Fachowe CeDeWu, Warszawa 2010, pp. 13-20.

[7] K. Olejniczak, Wpływ wybranych czynników ekologicznych aspektu CSR na przewagę konkurencyjną przedsiębiorstw działających na terenie województwa śląskiego, Annual Set Environment Protection 15 (2013) 2840-2849.

[8] I. Paprotna, Jak wdrożyć społeczną odpowiedzialność biznesu w firmie, Wyd. Level Sp. z o.o., Katowice 2011, p. 3.

[9] R. Hay, E. Gray, Social responsibilities of managers, Academy of Management Journal 17 (1) (1974) 135-143.

[10] E. Staniewska, Aspekty informatyczne działalności logistycznej przedsiębiorstw, Logistyka 6 (2013) 711-714.

[11] J. Dyczkowska, E-logistics operators—the digital technology in the sector TSL, Journal of Management and Finance 11 (1) (2013) 132.

[12] I. Malanowska, A. Koliński, Wykorzystanie narzędzi gospodarki elektronicznej w działalności przedsiębiorstw z sektora MSP, e-mentor 2 (2009) 79-80.

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Mathematical Debates as an Integral Part of the Learning Process

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Abstract: In this report, we want to touch upon two aspects of teaching mathematics in middle and high school. The first of them is the eternal question of how to teach, to motivate students and make them involved in the educational process, particularly in mathematics, where the most important factor is the natural gifts. The second aspect concerns the question which became very urgent in the modern world: what, in fact, we want to teach the students in a world over-saturated with information of any kind. As a result of the information blowup, two aspects emerge. On the one hand, straight passing over the skills and knowledge to the students becomes irrelevant today (just like a teacher or lecturer, merely speaking to an audience, who is not that relevant for young people, accustomed from childhood to perceive information through dynamic color visuals). On the other hand, there is a change in emphasis in the objective function of the educational process from gaining knowledge to acquisition of skills of working with information, consideration and estimation, and choosing of the optimal strategy of a number of possibilities. This trend can be seen in the selection of problems in the international examination PISA (Program for international Student Assessment), in the new curriculum in mathematics and in the selection of problems in the matriculation exams. These considerations (along with others) make teachers look for new forms of learning, more appropriate to the demands of modernity. In this report we suggest the idea of using a mathematical competition called "Mathematical debate" (mathematical fight) as an integral part of the educational process at different levels of learning mathematics, as an appropriate tool.

Key words: Mathematical debate, mathematical fight, program, mathematics and learning process.

1. Introduction

Mathematical Debates first emerged as a form of competition between school students about 70 years ago in Moscow and Leningrad mathematical boarding schools. This form of mathematical competitions quickly gained popularity among mathematical schools and clubs. Its purpose is not only to provide students the opportunity to solve mathematical problems of high complexity, but also to publicly present and defend their solutions, and argue against the solutions of their rivals. Special attention was paid to subtleties. The game helped to sharpen the mind, gain a better understanding of the foundations of elementary mathematics, and develop oratory skills. Today, accounts of city level, regional and cross regional mathematical debates held in physical and mathematical schools between different teams of gifted children can be found on the internet.

Some time ago we started to develop the idea of using a form of mathematical debates for a completely different purpose, targeting a different category of students. The idea is to] use the game as part of the educational process at various stages of learning. The method proved to be very useful for students of different ages (from middle school students to students of basic courses at higher educational institutions), and for students with different levels of

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mathematical ability, especially for weaker students, a point which we consider to be of great importance.

In order to understand how the method is used in our case, let us examine the essence of the game. The game takes place in two stages. At the first stage, the participants are divided into teams, each team receives a set of problems (all teams are given the same set) which they have to solve together in a given amount of time. Once time runs out, the second stage—the public presentation of solutions-begins. One team "challenges" another on a particular problem. The representative of the team that has been challenged has to present his team's solution, and the representative of the challenging team argues against him, checking the accuracy, precision and efficiency of the solution. The challenger can ask questions during the presentation of the solution and request further clarification.

Unlike classical mathematical debates, where the rules are strictly regulated, educational games allow variation of the form of the game depending on the educational purpose.

Consider the advantages of the described form in the light of problems raised above.

On the one hand, the very form of training in the form of "Mathematical debate" implies an active role of the student in the learning process in a variety of its forms: individual and collective work based on existing skills and knowledge, the search for the missing information, promotion of good and bad ideas, insights, disputes, a critical assessment of what he heard, the willingness to defend his point of view and, on the contrary, admit he was wrong, and much more. We get here a situation, similar to one, considered in the article of Goldin et al. (G.A. Goldin et al., "Beliefs and engagement structures: behind the affective dimension of mathematical learning"), which provides an opportunity to influence certain of its components. In addition to the standard desire: to find the answer to a problem, there are a lot of additional incentives to encourage student activity: the desire to win the competition, the desire to succeed in public speaking, the feeling of joy from a suddenly understood material. Finally, the excitement (action) as part of any game turns a lesson into alive and desirable part of the learning time. One example is the excited reaction of one of the students after such a lesson. He said about himself: "It is unbelievable how the main metal music fan in the class suddenly turned into the first "nerd"".

2. Related Work

In all the games we hitherto seen there is a clear trend of gradual transition from individual work (where everyone is trying to solve the problem on his own) to work in groups: first in small groups (e.g., consultation with a neighbor, moving closer to each other, a strong concentration around students or those who have more background material), and then the spontaneous formation of large groups of students interested in solving the problem.

Often such a group goes to work on the board, where it is possible to make large drawings and large records and there are conditions for multi-lateral discussion. Yet here everyone finds himself from one side in public, and from other side he feels himself part of a team with a certain degree of responsibility for its success. Affective categories (for example, to contribute to the victory) become an additional factor in relation of the student to the task at hand.

We now consider the advantages of the mathematical debate from the point of view of achieving educational goals: to deepen the understanding of the studied material, to achieve the "feedback" (often a student thinks that he understood the material, but in reality the image that arose in his mind does not correspond to what the teacher was trying to create, and only after hearing arguments of the student himself on the topic one can grasp the inconsistency), to translate passive knowledge of students to active knowledge in an active phase where students are free to apply them in different settings and contexts. In light of these goals, the main

advantage of the type of mathematical debates described above, which makes it an effective educational tool, is that each problem goes through several stages of collective discussion, the first of which occurs while the team is trying to reach a solution. Often, especially with weaker students, two students who belong to the same team get different results while solving the same problem, and since the team has to agree on a solution, this generates in-depth discussion of the studied material. In the process of these discussions obscure points are revealed and clarified, and students gain a better understanding of details.

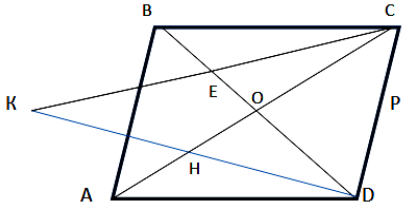
The next stage of the discussion also takes place within the team. According to the rules of the game, there presentative of the team is not chosen by the team, but either appointed by the jury or chosen randomly. Given this rule, all members of the team have to be able to present the solution equally well. Therefore, each problem goes through an additional stage of discussion which includes an explanation accessible to the weaker students. It should be noted that the above rule ensures the participation of all students, not just the stronger ones and the high achievers. For a weak student understanding and presenting another's solution is often no easy task, and if he succeeds at it (and the team is committed to helping him do that), this will often be his first successful experience in mathematics, which may motivate him to study more diligently in the future.

The third discussion of the problem occurs during the public presentation of the team's solution. At this stage, subtleties which the team may not have noticed before are often revealed. At all stages, and in particular on the latter it is crucial to use a technique called "peer review", the effectiveness of which is seen in the works of Yaniv Beaton.

Consider for example a geometry problem from one of math debates at various stages of its discussion. The problem is the following:

The diagonals of a parallelogram ABCD intersect at point O. The points E and H are respectively midpoints of BO and AO. P is the middle of the side DC of the parallelogram. K is the intersection of the extensions of segments DH and CE. Prove that the points P, O, K are collinear.

Let us follow the discussion that took place in one o f



the teams.

The drawing was originally built as follows: Immediately, one of the students asked, "Will the point K be always outside the parallelogram or we have to consider the cases when it is inside or lay on the side AB separately?" The team spent some time searching for the answer to this question, but failed to find it. The question was left open and, of course, was "saved" for the opponents.

For the case shown in the figure, one of the participants found quickly a solution:

The point O is the middle of BO, so BE = EO. Denote the length of these segments by x. So DO = 2x (as the diagonals of the parallelogram at the point of crossing are divided in halves). In the same way, AH = HO = y and CO = 2y. Thus, in the triangle CKD, CH and DE come out of the vertices of the triangle and the point of their intersection divides each of them in the ratio 2:1. From that one can conclude that they are medians of the triangle. Given that the point P is the midpoint of CD of the triangle, this implies that CD is also a median and passes through the point, quod erat demonstrandum (QED).

This solution caused a hotindignationin one of the teammates. He insisted that the converse of the theorem of the point of intersection of the medians in a triangle (stating that if two line segments coming out of the vertices of the triangle to the opposite sides get

divided at the point of intersection in the ratio of 2:1 from the top, then they are medians) is not necessarily true. And, even if it is correct, it requires a proof. The author of the solution plunged into search for a proof. He was sure he was right, but he considered the requirement as rightful.

Meanwhile, another player suggested an absolutely different solution:

EH is a middle line in the triangle ABO (E-mid-BO, H-mid AO, by condition). Consequently, by the theorem on the middle line of the triangle, EHll AB and equal to its half, i.e. EH = ½ AB. But AB = CD, AB ll CD (as opposite sides of the parallelogram). Hence, EH ll CD and EH is equal to half CD. Consequently, according to the inverse theorem on the central line (stating that a line segment connecting the two side of the triangle which parallel to the third side and equal to its half, is the middle line of the triangle) EH is a middle line of the triangle CKD. Hence, E and H are the middle of the sides concerned, and then O is the point of intersection of the medians, and therefore, the median KP passes through it, QED.

This solution did not get any objections. The converse theorem on the middle line was well known to pupils and proving it in case of need could not cause any difficulties. The team chose this solution.

The student who continued to think about the validity of the first solution , noticed that in the second solution the location of the point with respect to the parallelogram is not important, but it implies that it is out of the parallelogram , as it is proved that point E is the midpoint of the KC, the point O—the midpoint of AC (the intersection of diagonals of a parallelogram), so that EO is the middle line of the triangle CAK and EO ‖ AK , which is possible only if the point K is outside the parallelogram. By the way, he was succeeded to prove the inverse theorem on the point of intersection of the medians and, therefore, the validity of his solution. Thus, before the public part of the game the team had two thought-out and ready to be defended solutions (they voiced their preference for the second one) and a number of prepared questions in case they do not have to show solution, but oppose.

The second team found quickly a solution based on the division of segments in a ratio of 2:1 (the “first” one shown above). The solution did not raise additional questions and the team moved on to other jobs.

During the public phase of the game the second team was suggested to show the solution of this problem. The first team was to oppose.

The first question the opponent asked about the drawing: “Why do you consider only one from three possible locations of the point K?” A player, demonstrating the solution, tried to quickly answer the question. He succeeded to prove that the point K cannot lie on the side of the parallelogram, but the fact that it cannot be inside the parallelogram, he could not prove.

The next question was about using the Inverse Theorem. The opponent demanded to prove it (if it at all is true). This question put the defendant in a deadlock. The initiative passed to the opponent, and he performed a full analysis of the problem, attracted attention of all the participants (they were surprised at how many “pitfalls” got found in this seemingly easy ask).

The opponent brought to his team the most points for this problem, and it was a deserved reward for perseverance in the pursuit not only formally to solve the problem, but also to understand the problems described therein. Additionally all the participants were enriched by the proof of the inverse theorem on the medians of a triangle, which to that moment they have not been taught.

3. Conclusions

The idea of using mathematical debate as part of the educational process raises a lot of questions to be addressed, from the obvious, such as the selection of problems, to the fundamental question: is it possible to develop a universal scheme of such a lesson, so that

all teachers of math could use it, or role of the teacher is so great that such a method of teaching will remain the property of enthusiastic individuals? To date, we have tested the method with the students of the preparatory department of Technion, weak students of eighth, ninth grade, strong students of 9th and 11th grades. An interesting game on "research functions" was held between students of 9th and 11th grades, where the elder children were prohibited to use calculus. The results that we have seen seem to be interesting, and we expect to publish them.

References

[1] A. Domoshnitsky, R. Yavich, V. Bugaenko, A. Kannel-Belov, International mathematical internet olympiad, Journal of Systemics, Cybernetics and Informatics 10 (5) (2012) 50-54.

[2] Y. Biton, Incorporating peer assessment in pre-academic mathematics study, Ph.D. thesis, The Department of Education in Science and Technology, Technion, Haifa, 2011.

[3] Y. Biton, B. Koichu, Peer assessment and mathematical creativity, in: M. Avotina, D. Bonka, H. Meissner, L. Ramana, L. Sheffield, E. Velikova (Eds.), Proceedings of the 6th International Conference Creativity in Mathematics Education and the Education of Gifted Students, Latvia, 2011, pp. 30-34.

[4] A. Domoshnitsky, R. Yavich, Internet mathematical olympiad for students, mathematics competitions, Journal of the World Federation of National Mathematics Competitions Organizers 24 (1) (2011) 11-21.

[5] Y. Roman, Social networks and students, Research Journal of Management Sciences 2 (2) (2013) 1-2.

[6] N. Davidovich, R. Yavich, A. Domoshnitsky, Mathematical games: international mathematics olympiad for students, Far East Journal of Mathematical Education 9 (2) (2012) 133-140.

[7] A. Domoshnitsky, R. Yavich, Mathematical competitions for university students, in: Proceedings of the 10th International Conference Models in Developing Mathematics Education, Dresden, Saxony, Germany, 2009, pp. 143-145

[8] A. Domoshnitsky, R. Yavich, Internet mathematical olympiads, in: Proceedings of the 10th International Conference Models in Developing Mathematics Education, Dresden, Saxony, Germany, 2009.

[9] N. Davidovich, R. Yavich, Course websites and their contribution to students evaluation of instructors and their courses, Research Journal of Management Sciences 2 (3) (2013) 1-7.

[10] B.E. Starichenko, A.N. Egorov, R. Yavich, Features of application of classroom response system at the lectures in Russia and Israel, International Journal of Higher Education 2 (3) (2013) 23-27.

[11] R. Yavich, A. Gerkerova, Teaching methods and assessment, American Journal of Educational Research 1 (7) (2013) 260-262.

[12] G.A. Goldin, Y.M. Epstein, R.Y. Schorr, L.B. Warner, Beliefs and engagement structures: Behind the affective dimension of mathematical learning, ZDM Mathematics Education 43 (2011) 547-560.

[13] Yavich R (2014)-Computer Technology and Mathematics Teaching, ARPN Journal of Science and Technology 4 (2) (2014) 87-90.

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